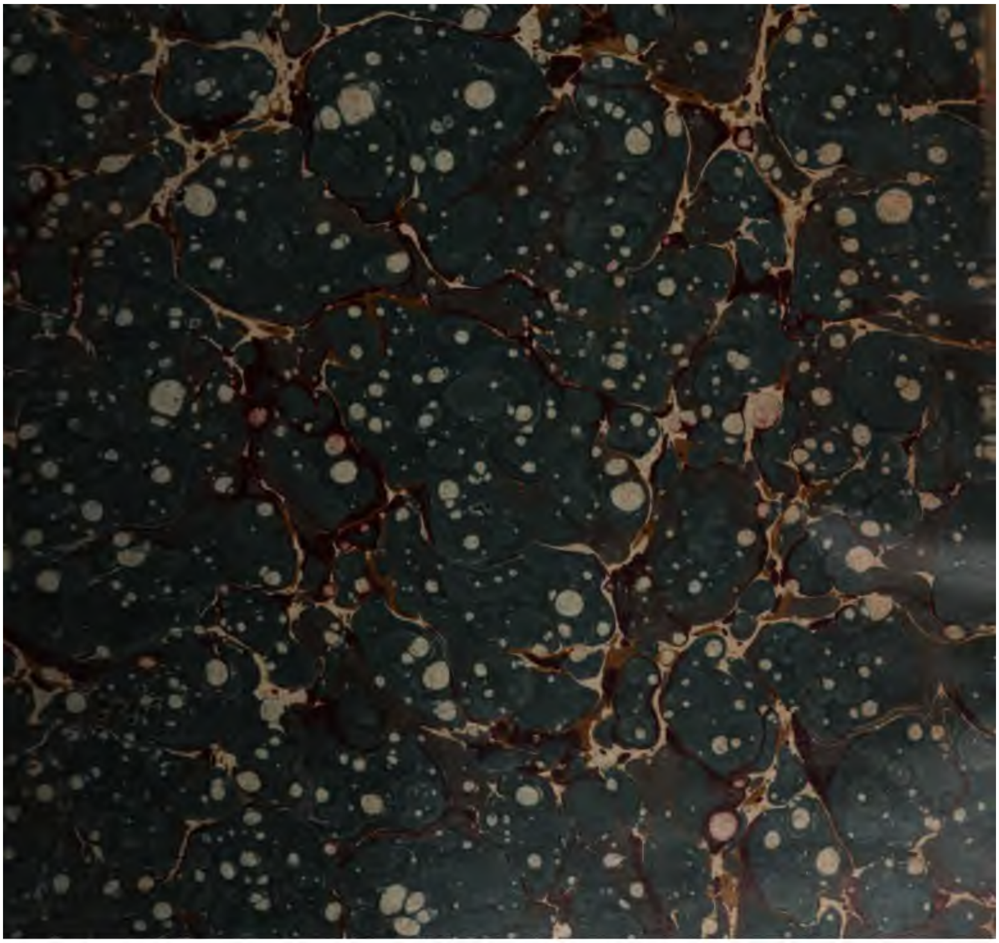

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THE

AMERICAN

JOURNAL OF PSYCHOLOGY

EDITED BY

G. STANLEY HALL,

E. C. SANFORD, Clark University. AND E. B. TITCHENER, Cornell University.

WITH THE CO-OPERATION OF

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CREEPING AND WALKING.

By AUGUST W. TRETTIEN.

When we look upon an infant which is just taking its first breath of vital air, we cannot but feel the full import of Linnæus's definition of it, when he said—"Naked and without weapons."

Other mammals possess natural means of protection and defence; some wear a warm fur, others possess agility and swiftness of foot soon after birth, but man has nothing of the kind for many months after he begins his separate existence.

We are also struck with the peculiar purposeless character of the movements of the human infant, apparently without control or rhythm, without administering to the immediate necessities of life. An infant, come to make its way through a life of necessity with only a possibility as its individual heritage.

On the other hand, we look upon man in his full possession of power and stature and contrast his form and appearance with that of other vertebrate creatures, we are equally struck with his capability of assuming an attitude which is distinctly his own, which has been termed the erect attitude. In this position the head is balanced perfectly upon the summit of the spine; the inferior extremities are elongated and brought into straight line with the body for support and locomotion, and the superior limbs hang gracefully at the side of a beautifully curved trunk. As Huxley says—"he stands raised up as on a mountain top, far above the lead of his humble fellows, and transfigured from his grosser nature by reflecting, here and there, a ray from the infinite source of truth."[1]

The whole position is in striking contrast with the attitude

[1] Man's Place in Nature. p. 132.

of the fishes of the sea, the fowls of the air or the beasts of the fields, whose long axis of body is parallel with the surface of the earth over which they move.

It is indeed strange that this erect attitude of the human body, which conjoins with it the discharge of the highest faculties of man, has not been heretofore a subject of more extended investigation.

It is the purpose of this study to trace the various stages and attitudes assumed by the infant and the movements which it employs in passing from this helpless stage of infancy to the time when the straightness and uprightness of body is taken. The data upon which this study is based, has been carefully selected from Medical Journals, Hospital Reports, and from the returns of a syllabus on the Straightness and Uprightness of Body. These returns have been the direct observations of individual cases and the writer has sought to verify the results by personal observations.

The Embryo.

Before we can approach the problem as it is presented to us in the infant at birth, it is necessary to consider briefly some of the determining factors during the embryonic life. At the stage of fœtal life when the embryonic body takes shape out of the embryonic disk, there is a conspicuous enlargement of the head and neck, as compared with the body, accompanied by a dilatation of the medullary canal to form the brain. Shortly the head makes a distinct bend forward and downward at about its middle, and the posterior end, which at first curves slightly upward, curls over ventrally, and as the back curves with it, the dorsal outline of the entire embryo becomes convex. This convexity increases so that in the embryo of about 30 days growth the head and tail closely approximate, having the (Fig. 12 72, p. 190, Vol. III, Buck's Rep. H. Book, m. sc.) form of the letter C, and is from four to eight mm. in length on the straight line.

The anterior and posterior limbs have already made their appearance as small buds on the two sides of the body. Soon the fore-arm, the leg, and the arm and thigh successively make their appearance.[1] M. Hamy took the measurements of Zue, Gunz and Liharzic, and showed that at about the fourteenth day of intrauterine life the fore-arm of the European is longer than the humerus, while from two and one-half months the humerus grows proportionately faster. At this period the ratio existing between the fore-arm and the arm is 88 to 100, at birth this ratio

[1] Topinard: Anthropology, p. 141. Reference Hand Book of Medical Science. Dr. Buck, Vol. III. Embryology. Dr. Minot.

is 77:100, and at maturity 72:100. The femur is also relatively small during this early period.

During the time to the fiftieth day of growth a well marked change takes place in the external form of the embryo. The body now becomes nearly straight, with an area about the same as that of the head; the limbs are distinctly divided into an upper and lower division; the hand makes its appearance with notches along the edge of the distal end from which converging grooves run; and two weeks later the five digits are well developed. The lower limbs are also divided, the feet are plainly marked, and the toes are becoming free. On the whole the development of the posterior extremities is outstripped by that of the anterior. The bend in the neck has diminished from a right angle to an obtuse angle. At the period of two months the embryo has a distinctly human appearance in all parts, despite the disproportions of the same. There is now an increased development of the legs and feet and the disappearance of the free tail. (Fig. 224, Minot, p. 392.) Measurements of the extremities of different fœtal skeletons at the approximate ages of four, six and eight months give the following results:

Length of Fœtus. Length in Inches.	Length of Spinal Column.	Length of Arm.	Length of Leg.	Age. Approximated According to Hacker.
7.80	4.12	2.72	2.80	4.4 mos.
10.77	4.94	3.86	4.07	5.4 "
15.70	6.67	5.51	6.18	7.9 "

The following table expresses the ratio of the extremities:

Age.	Length in Inches. Body.	Arm.	Leg.
4.4 mo.	7.80	100	102.9
5.4 "	10.77	100	105.6
7.9 "	15.70	100	112
17 "		100	136
[1]Adult.		100	143 } Taken from Hamy's Measurements.

Position in Utero.[3]

The position which the fœtus assumes in utero without doubt determines the position of the extremities with reference to the

[1]Topinard Anthropology, p. 85.

[2] The manner of estimating the age of these embryos was taken from Hacker's measurements, which show that the fœtus at three and four months is three and four inches respectively, at five, six, seven and eight months the average length may be determined in inches by doubling the time; at nine and ten months the length is seventeen and eighteen inches respectively.

[2] Diseases of Infancy and Childhood, Dr. Holt.

[3] Minot: Embryology, p. 394.

body for some weeks after birth, and consequently the early movements are affected.

In utero the head is bent forward, the back contains one continuous concave curve forward without the lumbar convexity of later development; the extremities are drawn toward the body, the arms are bent forward and crossed over the breast with the fingers touching; the legs are raised forward, the right leg nearly always straight across the body with the toes resting against the forehead, while the left leg is bent at the knee bringing the left foot against the right thigh. In another position, the legs are crossed over the lower abdomen. The babe rests generally upon the right side. This attitude gives the muscles the greatest relaxation, and to the cartilage, which caps the bones, the position most favorable to nutrition and growth. At the same time the embryo forms as nearly as possible an oval, and thus occupies the smallest possible space.

Prenatal Movements.

It is believed by Professor Preyer and others that the movements of the infant immediately after birth do not essentially differ from the parental movements, except that they are given a wider range. The parental movements are entirely purposeless and are spontaneous or reflex. The former are those movements which are due to diffused stimuli from the growth of the lower motor centers, the latter movements immediately follow external stimulation. Professor Preyer states as a certainty that these movements are present in an embryo at five months' growth, and to substantiate this statement he cites an experiment of Erbham, which shows conclusively that even at four months the movements are possible from the stage of development of the muscular and nervous systems. Erbham placed a four month fœtus into a small vessel of warm water which furnished a sufficient external stimulus to cause a contraction of the muscles of the extremities and neck, to move these members in a natural manner. For one-half hour it was observed that the limbs moved before the body and the head turned from side to side.

Medical writers who place the evidence of movements considerable later, usually refer to the larger movements of swallowing, clasping and stretching as outgrowths of he simpler reflex movements to which Prof. Preyer refers.[1]

Like every other organic formative process, the origin of the human body and of its nervous system appears as an expression of a life process in course of progress, the beginning of which we do not know. What we do know is that very early in

[1] Preyer: Physiologie des Embryo, p. 431.

the embryonic life, when the body and nervous system attain a certain stage of development, a disturbance without causes a nerve stimulus which in turn produces muscular contraction. The infant, before birth, is living in an environment where the external stimulation is limited, the amniotic fluid in which the fœtal body rests is of uniform temperature with the body, yet it receives peripheral stimulation which is transmitted to it from the body of the parent—the beating of the heart, the movements of respiration, the change of position and posture and the movements of walking, all have their direct influence in stimulating the organism of the fœtus.

These stimuli start the nerve mechanism which has become so complicated and interrelated that a given irritation never affects one cell only, but rather is conducted from a point in the periphery by the fiber to a nerve center which may innervate a large collection of motor cells. A subsequent stimulus in like manner excites a sensory cell, which according to the anatomical relations of the sensory and motor cells, may bring an entire system of muscles into contraction.

In this manner Exner has explained how a single sensory impression may lead to a complicated movement in which many muscles take part. There is a close relationship, says Edinger,[1] established between the different sensory nerves and their motor reactions, and there is much evidence in favor of the view that such relationships, when once established in the course of evolution, are afterwards inherited. The nervous system, then, consists of two parts—one part, which is congenital and arises from the primordial racial exercise (phylogenetic), and the other part (ontogenetic), which derives its relationship only during the individual person's life.

The congenital mechanisms are found in the nervous system of the embryo and predominate in the sympathetic system and in the medulla and pons. The latter centers correspond to Hughlings-Jackson's lowest level, in his three-level theory and control the simple reflex movements.

The Infant at Birth.

[2]A study of the infant at birth shows that it is a being still very different from the adult in the structure and composition of its organs as well as in the relative proportions of the members of its body.

The data for the study of new born infants is still very limited beyond that of the bare measurement of length and weight.

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[1] Edinger:

[2] Am. Jour. of Obstetrics, Vol. XXXVII, 1898. Dr. Wilson.

[1]The length of the infant at birth is about ⅓ of that of the adult. The average length has generally been taken as 50 centimeters (19.68 inches) for males and 49.50 centimeters (19.48 inches) for females.

The normal range of boys in height, as shown by the Report of the Anthropometric Committee of the British Association for the advancement of Science, is from 15 to 24 inches and of girls is from 16 to 23 inches.

The weight of an infant at birth is about $\frac{1}{19}$ of the adult weight. The average weight of a healthy child born at full time is 3,333 grams (7.3 lbs.) for males and 3,200 grams (7.1 lbs.) for females.

Again stating the figures of the Anthropometric Committee the boys range in weight from 3½ to 11½ lbs., and the girls range from 4½ to 10½ lbs. The report of the committee is based upon the measurements of 451 boys and 466 girls in London and Edinburgh hospitals and represents largely the measurements of the lower and middle classes of society. The parents were English and Scotch and represented city and country people. The measurement of the length was taken in a recumbent position and the weight without clothes.

Relative Proportions of the Parts of the Body.

While there are very great individual differences in infants in their stature, there are certain proportions which are maintained at all periods of growth between height and width. According to Dr. Uffelmann,[2] in the normal child, the measurement across the shoulders should equal about ¼ of the length of the entire body. An important difference is disclosed between boys and girls at birth. In stature and weight the girls are nearest the average type; in form the boys' shoulders and hips measure the same across; in girls, the shoulders measure a little less.

The following tables are given to show the relative increase of the different parts of the body at various periods of growth. Zeising's measurements represent a general law of proportion of the normal child, the measurements are taken from the crown to the hip and from the hip to the heel. At birth these measurements are about equal. Letting the whole length from head to heel be represented by 1,000 in each case, the relative length will be expressed as follows:

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[1]Vierordt K.: Anatomische, Physiologische und Physikalische Daten und Tabellen.

[2]Dr. Uffelmann: Domestic Hygiene of the Child, p. 7.

[1] Birth	$\frac{500}{500}$		
1 year	$\frac{478}{522}$	Increase of lower limbs	$\frac{22}{1000}$ in one year.
2 years	$\frac{457}{543}$	" " "	$\frac{21}{1000}$ " "
3 years	$\frac{439}{561}$	" " "	$\frac{16}{1000}$ " "
5 years	$\frac{415}{585}$	" " "	$\frac{12}{1000}$ " "
8 years	$\frac{397}{603}$	" " "	$\frac{6}{1000}$ " "
13 years	$\frac{382}{618}$	" " "	$\frac{8}{1000}$ " "

Growth in length of parts of body according to Liharzik's table.

[2]Representing length at birth by 100.

	Birth.	End of 21 month.	7½ year.	Adult.
Head,	100	150	191.7	200
Forehead,	100	114	150	157
Lower portion of face,	100	200	250	260
Neck,	100	500	700	900
Chest,	100	186	300	314
Abdomen,	100	160	240	260
Leg,	100	200	455	472
Arm,	100	182.5	325	350
Upper,	100	183	328	350
Lower,	100	182	322	350

The proportions of the infant's body are very different from those of the adult. The new-born has a very small and narrow thorax compared with the abdomen, and the pelvis as a region scarcely exists. The whole trunk thus assumes an oval form with the small end toward the neck.

[3]The anterior diameter of the thorax at birth at the level of the 2nd costal cartilage is as 2 to 3, while in the adult it varies from 1 to 2½ or 1 to 3. The sternum is relatively smaller than in the adult male, but not very different from some very small breast-bones which are occasionally found in women. The shoulders are very small, which make the chest appear quite different. The pelvis is so small that it forces the pelvic organs of later life more or less into the infant's abdomen.

Composition and Structure of the Body.

Bones. The composition and structure of the infants' bones are very different; the bones are softer and more vascular, the marrow is vastly more dilated with blood vessels. An ex-

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[1]Gerhardt: Handbuch der Kinderkrankheiten, pp. 267 and 269.
[2]Gerhardt: Handbuch der Kinderkrankheiten, p. 272.
[3]Dr. Rotch: Pediatrics.

tremely important difference is noticed between the spine of the new-born and the adult. In the infant the spine has little bone and much cartilage and fibrous tissue, making it light and flexible. The movements in the spine at birth are remarkable. Dr. Rotch ovserved that the spine of a child at birth, the abdominal visceral having been removed, could be bent easily so that the head touched the buttocks. The middle part was most flexible, the lumbar region seemed to be more pliant than the cervical. The lateral motion was quite free, though not without some torsion.

Curves. The spinal curves present an interesting and important condition.[1] In the infant, the whole dorso-lumbar region is concave forward, presenting one continuous curve from the neck to the sacrum, instead of the alternating convex curve forward in the region of the neck, a concave forward in the region of the chest vertebræ, succeeded by a convexity forward in the vertebræ of the loins. The adult vertebral column presents two sets of curves; the primary or dorsal and sacral curves which a e present in quadrupeds, with them the human infant begin .ts independent existence, and the old man takes themto his earthly abode; and the secondary or cervical and lumbar curves. These secondary curves, says Dr. Turner—"are the characteristic spinal curves of man." But Professor Cunningham noticed them in the chimpanzee and also in some quadrupeds (*e. g.*, bear). This plainly indicates that the secondary curves can be associated with the upright position.

In process of development, as will be shown in the subsequent chapters, there are three distinct stages in which the spinal column assumes a characteristic curvature. First the natural continuous curve at birth. Second the curve which appears in the cervical region when the infant has learned to sit and to support its head erect upon the trunk. Third the additional dorsal and increased lumbar curves which make their appearance when the child is able to stand and walk erect. These characteristic curves may even be produced in an infant when it assumes different positions. When it is lying in a normal position the spinal column presents the long convexity, if the head is thrown back there appears a slight convexity in the neck, if in addition the legs are drawn out the lumbar region will spring forward. The latter positions are not, however, natural in the infant.

The relative lengths of the different curves are different in the infant compared with the adult. The following tables from Aeby and Cunningham will clearly show the ratios.

[1] Nature: Vol. XXXIII, p. 378, 1886. Report of Brit. Assoc. for Adv. sc., 1897, p. 771.

Relative lengths of adult spinal curves according to Aeby. Total length=100.

	Cervical Region.	Dorsal Region.	Lumbar Region.
Females,	21.5	45.7	32.8
Males,	22.1	46.6	31.3

Cunningham's ratio from 6 males and 5 females.

Females,	21.6	45.8	32.8
Males,	21.8	46.5	31.7

Relative lengths of spine curves according to Aeby's measurements of 5 and Cunningham's measurements of 3 infants.

Aeby,	25.6	47.6	26.8
Cunningham,	25.1	48.5	26.4

Other measurements of the lengths of infants' spines from the head to the sacrum.

		Absolute Length in M. M.				Rel. Length. Total=100.		
Observer.	Age of Infant.	Cerv.	Dorsal.	Lum	Tot.	Cerv.	Dor.	Lum.
Rasenel,	3 mos.	50.	100.	58.	208.	24.	48.1	27.9
Aeby,	6 "	52.5	103.	60.	215.5	24.3	47.5	27.8
Aeby,	6 "	53.5	107.	61.	221.5	24.1	48.6	27.5
Dwight,	10 "	61.	125.	77.	263.	23.2	47.5	29.2
Rasenell,	2 years,	70.	140.	90.	300.	23.3	46.7	30.
Aeby,	2 "	79.5	153.5	98.	331.	24.	46.4	29.6
Dwight,	3 "	78.	162.	101.	341.	22.9	47.5	29.6

The table, if continued, would show that after the 5th or 6th year the proportion remains about constant.

In spite of the individual variations and personal equations due to measurements of the different men, the tables show a marked uniformity. There is, it appears, a fuller development of the upper part of the skeleton at birth than the lower.[1]

The infant's spine thus approximates that of the quadruped until it attains the age of a year or sixteen months, which is the usual so-called creeping stage. At the time when the hips and the knee-joints are completely extended and gradually draw the leg into line with the thigh the alternating series of curves in the spine appear. In this position the center of gravity is brought directly over the base, which enables the being to stand and move about on two feet with the greatest ease and the least expenditure of energy.

Muscles. The muscles of the infant are very small and soft and not until the sixth month do they become firm and resisting. Certain muscles are more highly developed at birth than others. Thus a noteworthy difference is observed between the muscles of the arms and the legs. Although the gastro cnémius

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[1] Rotch: Pediatrics, p. 56.

and the soleus muscles are developed sufficiently in body to form the calf of the leg, and the gluteus maximus is enlarged into the buttock, proportionally and in function these muscles are in a very rudimentary state compared with the muscles of the arms.

Dr. Robinson[2] found that in the case of sixty infants under one month of age, there was an exceedingly strong grip of the hands. He found that within one hour after birth they could hang by their hands onto the finger or stick ¾ of an inch in diameter, sustaining the weight of the entire body for a period varying from two seconds to one minute. Twelve out of the sixty could hang suspended ½ minute and four nearly a minute. This strength of grasp increased very rapidly after four days; nearly all ½ minute at that time. The faculty apparently attained its maximum development at two or three weeks, several children hung suspended over 1½ minutes, 2 hung a little over two minutes and 1 hung 2½ minutes. During that time of suspense no sign of distress or pain was evinced, no cry was uttered until the grasp began to give way.

This experiment shows that the hand and arm are developed functionally at birth, and the proportions are in striking contrast with the flexed position of the foot and thigh. The picture of a suspended infant reminded Dr. Robinson of a favorite chimpanzee "Sally" in the zoölogical garden.

The muscles of the neck are also in a rudimentary state of development; unless supported the head rolls off the infant's shoulders like a ball. The head can be rotated through an arc of 90° even without using the joint between the atlas and axis. The remarkable strength of the flexor muscles in the infant's body in comparison with the flaccid and feeble state of the entire muscular system is a striking phenomenon whatever may be its explanation.

Surface Anatomy.[3] Another exceedingly important difference between the infant and the adult will appear in a study of the surface anatomy of the spine. In the adult, especially in the male where the muscular system is well developed, there is a depression wherever the skeleton shows a prominence owing to the attachment of the muscles. The skeleton shows a ridge of spines in the middle line of the back, with a depression on either side; during the normal development of the muscular system there is a median furrow formed by two large masses of muscles in which the vertebræ appear prominent. In the infant this is not the case except in the neck. The back is rounded, later devel-

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[1] Huxley: Anatomy of Vertebrate Animals, p. 414. Rotch: Pediatrics. Turner: Report of Brit. Assoc. for Adv. of Sc., 1897, p. 768.
[2] Nineteenth Century, Vol. XXX.
[3] Rotch: Pediatrics.

opment flattens the back and brings the spinous processes into prominence without the marked median groove, this appears only when the muscles of the back become fully developed. The laminæ, in the infant, look more directly back, and their presence in the median line is marked by knobs and ridges very different from the spine of the adult. Little change takes place in the appearance and proportions of the infant spine up to 18 months, but at three years the adult condition is very markedly approached.

Early Movements. If we compare the new-born human infant with young of other vertebrates generally, we find also a striking difference in its capabilities of assuming the characteristic attitude of its specie. The fish assumes its position and moves off in its element as soon as hatched; the chick can stand upon its feet immediately after it is liberated from the shell; the calf or colt follows its parent a few hours after birth. But the infant is most helpless of them all. The early movements of the quadruped are directed toward the end making for its existence. The movements of the human infant are vague, stretching, reflex actions, entirely purposeless, usually performed in a jerking manner, except in some cases the hand after several random attempts accidentally finds the mouth. There is no co-ordination of movements in the infant, but the movements are entirely spontaneous, arising from individual centers without any order or time of action so far as known, and not determined through the senses. Dr. Mumford[2] concludes that these spontaneous movements are not determined by forces in the environment, so far as we can see, but that the nerve centers which produce them act separately and respond as such to a specific stimulus—a reflex action; if you tickle the sole of the foot the member is withdrawn, place the finger in the palm of the infant's hand and the fingers close about it.

A further study of the movements of the infant, especially the movements of the limbs, shows how entirely purposeless they are. After a time these spontaneous movements diminish and disappear entirely or become transformed into surviving movements.

Dr. Mumford holds that, though these early infantile movements are aimless so far as the individual performing them is concerned, they are not necessarily meaningless as regards the development of the race of which the individual is an off-shoot. He believes that it is quite probable that these movements are vestiges of functions of the limbs which were of prime importance to the members of the race at another and an earlier period of its growth; but that they began to lose their prime

[2] Brain, Vol. XX, p. 290.

importance and consequently their full development when the fore-limbs of the race gradually acquired other and higher functions. The theory is suggestive and ingenious; but it is only suggestive. In the light of the preceding investigations let us turn to the returns of the topical syllabus. Although limited in number, the returns were quite full in detail and also unanimous in the conclusions based upon actual observations.

TOPICAL SYLLABUS.

STRAIGHTNESS AND UPRIGHTNESS OF BODY.

This circular seeks information from those who have access to children on any or all of the following points which are to be co-ordinated in a study of the many stages by which an infant acquires its power to get into and to maintain its upright position.

Name of observer. Age of child.
Date. Sex.
Time since observation was made.

1. *Measurements.* Arms-length; size above elbow; below; Legs-length; size above knee; below. Measure length of limbs from body to tips.

2. *Arms.* Are fingers bent waking; sleeping; clenched waking; sleeping? Are wrists bent; elbows; shoulders? Do arms lie toward front; side? Are movements of arms toward front; side?

3. *Chest.* Does chest grow flat; deep front to back? Do shoulders grow apart; together; high; low; square; sloping? Do shoulder blades grow apart; together?

4. *Legs.* As child lies on its back are legs bent at hips; knees; ankles? Is the sole of foot turned inward; outward? Are feet turned up; down? Position of toes—bent {up; down; straight; used as fingers? Motion of legs front; side?

5. Describe first efforts to sit up; (a) how propped up; (b) in what direction is the body most apt to tip over; (c) does the child reach best front or sideways?

6. Describe the process of getting the head upright or balanced on the neck; its rolling off; learning to save the head from bumping when it tips over, saving a bump by hands and arms.

7. Describe early uses of leg and feet that anticipates standing and walking; as rhythmic moving, kicking, pushing feet against a vertical surface.

8. *Creeping.* (a) First efforts to turn over on the belly, to get head up; (b) to prop up front part of body with hands; describe any and every kind of creeping or locomotion before the upright position; (c) writhing along worm-like; (d) hitching in sitting position with one or both feet or alternately; (e) getting and going on hands and toes, elbows and feet, hands and knees, knees and elbows; (f) in progression how do the limbs act, one side together as in rocking limbs at opposite corners of the body together, or in what order, using the following

ra
ll
la
rl

e. g., to signify first the right arm, the left leg, the left arm, and last, the right leg. If ra and ll act simultaneously, place them on the same line.

9. Describe exceptional modes of progress fully, *e. g.*, rolling, going backwards, on one side, swimming movements, etc.

10. How do children first learn to go up and down stairs, get off of a bed, a chair, and any other things involving change of verticality of body.

11. First efforts to stand, in detail; (a) how made, beside or holding to what; (b) conscious or unconscious; (c) what effects on breath, gesture, feeling, etc., of first successful effort; (d) effect of falls.

12. *First steps.* (a) Are they beside walls or how; (b) first steps alone and unsupported, conscious or unconscious; (c) after the first step, and confidence is acquired do the children you know tend to walk too much; (d) effects and dangers of fatigue; (e) of illness; (f) is there a marked increase in size and fullness of legs at this time; (g) what new propensities as that to run away, more use of hands; (h) is there danger of prematurity or postmaturity in walking, should adults help? Why? Why not?

13. *Reversion.* When does child revert to creeping after he has learned to walk; when fatigued; in a hurry; excited; after sickness; after fall? Why? Revert to early manner of creeping; later?

***Miscellaneous.* (a) Does the spine hollow to co-operate, as angle at hip, straighten out; (b) give illustrations of children's propensity to climb; (c) describe increasing power of balance, power to stand on one foot, age at first jump, run, hop. (d) have you noticed any changes in health, appetite, circulation, temper, spirits or anything else your thoughts might be connected, as cause or result of learning to walk, sit, or any other stages.**

Please write out fully any peculiarities the child may have.

Send returns to

G. STANLEY HALL,
or A. W. TRETTIEN.

CLARK UNIVERSITY,
Worcester, Mass., Jan. 26, 1900.

I. The measurements under number one were made by the writer under as nearly uniform conditions as possible. Although the number of measurements of individual children was limited, the extremes appear, so that in general they give an index of growth.

The figures given here are the general averages and extremes, representing corresponding measurements of the arm and leg. In each case the measurement of the arm is represented by 100.

Average of measurements of males at birth.

Length of arm and leg,	100 : 134.
Circumference of limbs above knee and elbow joints,	100 : 146.5
Circumference of limbs below knee and elbow joints,	100 : 115.

Average of measurements of females at birth.

Length of arm and leg,	100 : 124.
Circumference of limbs above knee and elbow joints,	100 : 143.5
Circumference of limbs below knee and elbow joints,	100 : 114.5

Extremes in measurements of the length of limbs.

Males at birth.		Females at birth.	
Shortest,	100 : 105.	Shortest,	100 : 116.6
Longest,	100 : 150.	Longest,	100 : 137.

The tables of the Anthropometric Committee show that males at birth are a little taller and heavier than females, it also shows that there are greater extremes among males than among females. The figures presented here clearly show the same development with regard to extremities. Males at birth average a greater length, their lower extremities are proportionately longer, but they also present greater extremes.

II. *Arms.* The returns represent observations upon 182 infants; 93 males and 89 females. The results may be tabulated as followed, expressed in per centum.

Fingers.	Males.	Females.	Total Average.
Clenched	83	87	85
Bent	12	4	8
Straight	5	9	7

Wrists—Of the 109 returns, 51 were observations of males and 58 females.

Bent	69	65	67
Straight	31	35	33

Elbows—110 observations; 53 males, 57 females.

Bent	100	96	98
Straight	000	4	2

Shoulders—58 observations; 27 males, 31 females.

Bent	66	68	67
Straight	34	32	33

Arms—98 observations; 47 males, 51 females.

Lay front	98	92	95
Side	2	8	5

The returns of Number 2 show that the arms lay forward from the shoulder, the movements are toward the front in 97% of the 96 observations recorded, only 3% found it difficult to move toward the front and easier toward the side. The elbows and fingers are bent in a large majority of cases; of the 110 observations made, there were found four whose elbows were straight and these were all females. In the case of the wrist there is a difference, 67% of the 109 observations made show the wrist to be bent. Thus the arm and hand tend to retain the prenatal position for some months after birth. This is especially noticeable while the infant is asleep and the limbs assume the position which is most natural to its organization.

The arms are often folded over the chest as they were before birth.

The hand at this time furnishes an interesting study of reflex action. The fingers close firmly on any object placed in the palm of the hand. Miss Shinn noticed that an object placed in the hand was seized and carried to the mouth long before purposive movements had developed. The spontaneous movements are almost constant in some children when awake and in others when asleep. They occur as slow and apparently irregular with alternating periods of rest when the movement ceases or is inhibited by some other form of movement. Dr. Francis Warner[1] observed that the movement of the fingers may be temporarily arrested by a bright object before the eyes or a sudden sound; this arrest, after many repetitions, may be followed by a new series of movements occurring upon less and less stimulation and with increasing quickness and accuracy as time goes on.

An interesting chart has been prepared by Dr. Warner tracing these irregular spontaneous movements of an infant's hand for fifteen minutes when 9 days old. The chart also shows the inhibition of these movements by sight and sound. Miss Shinn[2] observes that while the spontaneous movements may be inhibited by co-ordinated movements from the first to the third month after birth when the child is awake, they may persist in sleep for several years.

Dr. Mumford[3] has carefully studied the development of the independent action of the thumb and the power of opposing it to the rest of the hand. During the early weeks the thumb appears to be a quite useless member, the hand ignores it in its grasping. Small objects are held between the fingers or between the fingers and the palm with the thumb either turned in with the object or extending outside. Only after two or three months does the thumb reverse to oppose the hand. Dr. Preyer found this development appearing the 12th week, Miss Shinn the 9th week and Dr. Mumford the 14th week. With the fuller development of the thumb appears the searching and investigating movements of the index finger. The finger is pointed at objects or carried in advance of the hand as a scout sent out to explore a new and strange environment.

1. Fingers.

1. F., 4 wks. She kept her fingers clenched both awake and asleep, but more especially while asleep.

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[1] Journal of Mental Science, Vol. XXXV, No. CXLIX. New Series, No. 113, p. 37.

[2] Shinn: Notes on Development of a Child, Plates III and IV.

[3] Brain, Vol. XX, p. 303.

2. M., 3 wks. His fingers were clenched both wehn awake and asleep.
3. M., 2 wks. When awake his fingers were bent, but when asleep his fingers were clenched.
4. M., 2 wks. The fingers of the baby are not clenched, but only a little bent when awake, but when asleep they are clenched tight.
5. M., 5 mos. The fingers are bent and in constant motion when awake and asleep.
6. F., 2½ mos. Kept her hands closed when awake and open when asleep.
7. M., 2 wks. The fingers were clenched when awake but clenched tighter when asleep.
8. M., 3 wks. When awake the fingers are not clenched, when asleep the fingers are clenched.
9. F., 3¼ mos. The fingers are bent loosely, and the fourth finger sticks out straight.
10. M., 4 wks. During the early weeks of life the fingers are clenched when awake and bent when asleep.
11. M., 4 days. Fingers were clenched when asleep and bent when awake.
12. M., 3 wks. If disturbed in sleep the little fingers would spread out like a fan.
13. F., 1 wk. The fingers are slightly turned at the tips.
14. M., 6 wks. When awake the fingers are moving inward, he puts his hand out straight with his fingers as far apart as he can. When asleep the fingers are bent.
15. F., 8 wks. The baby's fingers are generally tightly closed when awake, except when in pain they are clenched.
16. M., 4 wks. The fingers are clenched so tightly that the nurse must pry them open in order to wash the palm.

2. Arms.

1. F., 4 wks. She would always keep her elbow bent and would seldom attempt to hold the arm straight.
2. M., 2 wks. The wrists are but slightly bent; the elbow is considerably bent.
3. M., 5 mos. The wrists are bent inward.
4. M., 3 wks. The wrists and elbows are bent.
5. F., 3¼ mos. The arms are bent from the elbows when asleep and crossed over the breast so that the right hand is below the left.
6. M., 3 wks. The movements are toward the front usually, the little hands double up when resting on the chest.
7. F., 1 wk. The little hands are clasped over its chest, if it has its little shawl on it will also clasp it in its arms.
8. m., 6 wks. When asleep the arms are folded across the chest so that the left hand is near the mouth and the right a little below it.

III. Chest.

The movements of the infant's arms are limited to the plains extending forward from the body. The shoulder-joint is most free, the elbows and wrists are quite rigid, and it is only gradually that the infant acquires the ability to move its arms sidewise or to move its joint freely.

The answer to these conditions will appear in part from a tudy of the chest and its development. A study of the returns

shows that the growth of the chest continues along two lines—in depth and sideways.

In the prenatal stage the position of the arms is across the chest, the shoulders are brought forward, the shoulder-blades separated, giving the whole body a round appearance. As growth continues after birth the tendency is to push out along the line of least resistance, the sternum is cartilaginous, consequently the chest walls are pushed forward and a little side of the median line, the body grows in depth from front back. This development carries the shoulders back and up or back and down, the shoulder-blades approach one another, the back becomes straight and the shoulders square or sloping.

One observer says—that "at first the shoulders grew up, then after 3 mos. they gradually grew sloping." Another says—"Florence's shoulders grew very square; the shoulder-blades grew so close together that the whole body was pulled back." This is the natural course assumed by the body as it changes its position from the curved or stooping attitude to the erect. An observer who noticed the fact and not the cause, says: "The shoulder-blades grow together, for as the baby learns to straighten up, she throws her shoulders back." Another manner of growth is that in which the chest grows in width and apparently becomes flat, in this case the shoulders and shoulder-blades are crowded apart. The back keeps pace with the chest. Out of 79 observations made 37% of males and 53% of females developed sideways, their chests becoming flat and broad. With this development the shoulder is brought back, so that a wider range of movement becomes possible, and one great advancement toward adult movements is made.

1. Arm Movements.

1. F., 4 wks. All her movements were more toward the front of the body, and only gradually off to the side.

2. M., 3 wks. The arms move up in front first.

3. F., 3 mos. Her arms tend to lie more to the front of the body and the arms move forward.

4. M., 4 wks. Movements of his arms were in front of the body when lying on my lap.

5. M. The child does not make movements toward the sides until about 9 months old.

6. F., 5 wks. If the child wishes to reach sidewise from its body it will turn its body to face the object and then extend its hand.

2. Chest.

1. F., 3 mos. When Magdelena was small her chest was very deep, but after she was about 3 mos. old her chest seemed full.

2. M., 6 mos. The baby seems to be growing thicker through, the shoulders are growing more square.

3. F., 3¼ mos. The chest grows from front to back in depth. Her shoulders grow square and high.

4. F., Birth. The chest grows sideways, the child grows broader.

5. M., 3 wks. The chest develops sideways, the shoulders grow apart.
6. M. The early year of Herbert's life his chest grew in depth; his shoulders grew apart; his shoulder-blades grew together; and his shoulders grew low and sloping.

IV. Leg.

The prenatal position of the feet is maintained after birth for some weeks, up to the time the limbs prepare for the creeping and walking stages. The legs are bent at the hip-joint bringing them forward. The knees are bent and usually turned out a little; the feet cross, with the right foot laid over the left, and are turned up with the soles toward the median line. The toes are usually curled under toward the sole of the foot; occasionally one is found where the toes spread apart and extend out straight from the foot. Often the great toe is found to be far separated from the other toes, with the tendency to oppose it to the sole of the foot. The greatest freedom of movement at first occurs at the the hip-joints, with less at the knees and little at the ankle-joints. The movements of the legs, as of the arms are front and back, rarely toward the side. It is a very frequent occurrence to use the feet as hands in seizing objects and carrying them forward to the hands and mouth, the storehouse of all captured prizes. Several instances from observers will illustrate this. One speaks of the spontaneous movements of the opening and closing of the toes, similar to the movements of the fingers, when the child was awake and asleep. Another states that the toes would seize and hold a pencil or other object of proper size and hold it so tight that it was difficult to remove it, or it would seize and hold the edge of its shirt as if it were using its fingers. Another child would work its way toward the foot of its couch until its feet touched the perpendicular round sticks at the foot of the crib, the foot would then attempt to grasp the sticks, finding them too large for its grasp it would move its foot from one to the other until it came to the central wire which it could encircle and this it seized and held firmly. Another observer states a peculiar tendency in a child 7 months old,—if the child saw an object she wanted, which could not be reached with her hands she would reach for it with her foot, if successful, she pulled it along with her foot until it was near enough to reach it with her hand. It is not necessary to multiply instances any further to remind one of the cunning devices of the little anthropoids in the menageries reaching for their peanuts.

1. M., 10 mos. When laid on back the feet are crossed and turned upward. The motion of the legs is toward front, side movement was developed at about the 9th month. The child was called "Little Turk," from the position of his legs.
2. M. 5½ mos. When Robert lies on his back his legs are bent and

he immediately raises them forward to seize with both hands, and carries them to his mouth. The knee is bent, and with the sole of the foot is bent inward; the ankles are bent out; the foot is bent downward; the toes are curled under. The motion of the legs is forward. He grasps the stockings with his toes.

3. M., 9 wks. The great toe is separated from the others and is moved more.

4. F., 2½ mos. When the child lies on its back the legs are curved and crossed. They are not mobile, and the mother has hard work to pull them straight. The toes are spread. The movement of the legs is forward at first.

5. M., 2 mos. The legs are curved inward; the feet are turned downward; the toes are close together and turned backward. The motion of the legs is decidedly toward the front.

6. F., 3 mos. When lying on her back the legs are bent at the knee and at the ankle. The soles of the feet are bent inward and the feet are turned upward. The toes are spread apart.

Treatment of Infants among Primitive Peoples.

We have now arrived at one of the most interesting points in the process of development of the child, that is from the time when the head is balanced upon the summit of the spine and the body begins to rise into a sitting position, to the time that the child takes its first steps. This period is important, for the ignorance of parents and nurses have caused many a child to spend its life a poor deformed creature at the mercy of society. To know whether it is normal for a child to develop the power of co-ordination and thus to sit or stand alone, to understand the childish actions, whether in creeping or walking, is a lesson which has taken the human race a long time to learn; and certain parts of it, even in civilized lands, have not yet learned the lesson.

It will not be amiss here to cite several instances of practices among some of the primitive as well as customs among civilized people to which infants are subjected. Dr. Ploss[1] has said that "the manner of treatment of the child is a very accurate standard of the stage of civilization of a people." No truer words than these were ever spoken. Superstition and ignorance are the two mistresses who hold the keys which unlock the treasure house and set truth free. They are also the stumbling blocks in the way of progress for individuals and races.

Primitive as well as civilized people have looked upon infant development as an unnatural process. They have had an entirely false conception of the natural development of the body and its various organs and their functioning at a proper time, if not interfered with. If left to nature, according to these people, the body would not assume a proper attitude, therefore they seek to aid the natural growth by mechanical treatment of body and limbs to bring about their ideal forms, and it is need-

[1] Das Kind, Vol. II, p. 50.

less to say that such means operate directly against the end sought.

Dr. Ploss[1] tell us that the Wahumba and their allies, the Wakuafi in East Africa, have a practice of binding the lower part of the leg of the infant, from the ankle to the knee, with a bandage which remains until the infant grows strong enough to raise its body and sit up. By this compression they seek to interfere with the development of the calf of the leg, which, according to their notion, interferes with fast and continuous walking. The Maori women of New Zealand daily put all joints through a process of bending, the fingers are drawn out and the limbs stretched to make them limber. Certain tribes of Australia exercise the limbs of the new-born in the following manner:—A roll of muka is tied quite tight around the knee of the child in order to give it straight limbs, its arms and legs are drawn out daily, while the hands and fingers are bound firmly to keep them in the proper position. The soft flesh is often so compressed underneath the bandage that it is forced out at the sides. These people place much significance upon this shaping of the body, and the mother is considered as neglecting the sacred duty toward her child, if she does not, by artificial means, have the calf of its leg conform to the statutory provisions.

It is the custom of the Kalmückin to place a definitely formed wedge between the legs of the child in order to bend them according to the prescribed custom that they may be the more properly adjusted for riding. Certain Armenian people, after the 15th day of an infant's birth, thoroughly stretch the shoulders daily, pull out the legs and arms, press each muscle and joint, raise the head and stretch the neck to give it its proper length, or the child is suspended by its feet and allowed to swing back and forth several times like a pendulum, then it is turned about end for end and the process repeated. The Russians press every muscle and member of the body at birth, on the second day the infant is rubbed and whipped with a bundle of birch twigs, then it is snatched up quickly by the feet in order to properly adjust the members of the body.

Even the Germans had an early custom which is practiced in some sections of the country to-day, where the pressing and stretching process was employed to beautify the body. In modern times in Europe and America, the horse-collar, a sewing-machine cover and other means are employed to aid the infant in sitting up, or it is tied in a chair and allowed to remain so that the weight of the head and trunk becomes too great to be supported by the soft and growing bones. Or children are encouraged to walk by putting them into a walking chair before the

[1] Ploss: Das Kind, Vol. I, p. 334.

limbs can support the weight of the body, thus endangering their normal development. Our age of civilization is not yet freed from the results and methods of infant torture which were inflicted upon it for both their artistic effect and also to hasten the child's normal development. From these illustrations we see that there was lacking in primitive people and even among some of the civilized people to-day a proper appreciation of the normal development of the child. And one of the greatest drawbacks of a proper appreciation is a lack of precise facts concerning the healthy child.

During the early months some people believe that the child must learn to "sit up," and consequently they carry it erect on their arms during the first weeks of its life, later it is placed in an erect attitude upon the floor or in a chair. The chair was used early in history as a means of teaching the child to sit. The early Romans used it; it was found in the early Middle Ages throughout Europe. Travellers[1] to different parts have found the chair among natives. In Queen Charlotte's Island, voyagers found the native women using a small chair made of three pieces of bark fastened in a convenient manner. In this chair the child was placed, after it was rolled in the skin of a wild beast and fastened securely. Here the little thing was fed and rocked to sleep. Among the Esquimos on the Yukon, Mr. Whymper saw small chairs made of birch bark, in these a mossy seat was made and the little fellow was securely tied so that the mother could carry the chair and child wherever she pleased. The Chinese and Dutch have gone a step further and have combined the sitting with walking and have placed the child in a chair with rollers so that as the little one begins to walk it can push its chair with it, they have also added a table with a complete outfit of playthings and even school work is here introduced.

The chair, however, is an article not yet known among many primitive peoples. They let the child wallow upon the ground and let it learn according to its own unfolding strength and by its own intuition and observation. This is not only true of the primitive people but also of many of the Oriental who sit upon low cushions or squat upon the ground with their feet under them. And it has been observed that when the adults of a race assume these postures in sitting, the children learn the same by imitation. Examples may be cited upon this point from travellers' records. Thus, the Motu, a tribe in New Guinea, have a custom in which the men, in sitting, usually assume the squatting posture placing the soles of their feet firmly upon the ground and rest the buttock upon the heels. The women and children

[1] Ploss: Das Kind, Vol. II.

usually sit down upon the ground with their legs extending before them. The Popuas and Malays, the Negrites and Filipinos, assume similar positions when resting. As the children naturally follow and imitate the mothers earlier than the fathers they sit as the mothers do. At first on the mother's knees resting their backs against her body, then with increasing strength they assume the positions alone.

Locomotion of Infants of Primitive People.

Travellers have also noticed a similar peculiarity in the manner of locomotion of the children of certain tribes which are characteristic. The Arabian children as well as those of some of the tribes of Africa have a different manner of creeping from the European children. Instead of creeping on their hands and knees as the little Anglo-Saxon is wont to do, they sit up and slide along by hitching. Dr. Livingstone says in his "Last Trip through Central Africa," "The Manyuema children do not creep like European children upon their hands and knees, but begin their locomotion by placing one foot forward and rest upon the other knee, usually they employ both feet and both hands, but never both knees. The Arabian children employ the same means, they move along on both feet and assist in pushing with both hands." The children of these primitive people learn to walk much earlier than do the European and American children. Dr. Gräffe observed on the Island of Samoa that children of 9 and 10 months followed their mothers with tottering steps.

The usual manner of infant locomotion among primitive people, and some Oriental, is one of several rather exceptional means employed by the children of higher civilization. Anthropology has not yet answered the cause of this difference. Whether it is due to physical structure of the body or to mental characteristics and customs. Though students are inclined to accept the latter view.

Mr. R. W. Shufeldt[1] describes the acts of an infant about 10 months old which he saw while visiting the Navajos, an indian tribe inhabiting parts of New Mexico. He had been about the huts trying to secure pictures with a camera when he saw in a path, leading from one hut to another, an infant toddling along which he believed about 10 months old. The little fellow came down the path to about 30 feet from where Mr. Shufeldt had planted his camera in readiness for this little victim. Seeing the situation, the child very cautiously left the path and was in a moment behind a sage-brush growing along side the path. From this position he peered through the leafless twigs. Mr.

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[1] Nature, Vol. XXXV, 1887.

Shufeldt then tried to focus his instrument anew; while his head was concealed for a moment, the little lad ran to the next brush about 10 feet distauce toward the hut he was approaching and from there, crouched down and stared like a young lynx. At this Mr. Shufeldt took his instrument and approached him in this place, but upon arising he had scampered to the next brush. Now becoming desperate, lest he should lose his picture, Mr. Shufeldt ran to the place of concealment and pointed his camera three feet from the little fellow's face. At this last resort the child stood perfectly erect and gave for the first time vent to his infantile bawl and made a desperate break for the final point of his destination as there was nothing else left for him to do. This ability and cunning was displayed by a child 10 months old.

Psychological Aspect of Spontaneous and Voluntary Movements of Infants.

During the early months of the child's life we accordingly see important changes taking place, the spontaneous movements are very gradually disappearing, and in their place appear the conscious reactions, even apparently shut voluntary efforts. This is the period of gradual transition from the racial to the individual experience. The child learns to carry its hand to its mouth, the movements of the arms and legs which were so jerky and vague assume a more rhythmic and controlled character. What changes are taking place in this transition from the purposeless to the volitional movements? Several theories have been advanced in explanation of this step. Ribot considers the acquired movements, like walking, inherited and defines inherited as something that was at some time acquired but since has become fixed and rendered organic by numerous repetitions. It is organic memory. Spaulding[1] maintained that "the progress of the infant is but the unfolding of inherited powers." C. Lloyd Morgan[2] in answer to this says, "Spaulding went too far. Such unfolding there is, but it is under the guidance of individual experience. The regular flexions and extensions of the legs, 'which appear even months before the first successful attempts to walk, when the child, held upright on the floor, is pushed forward,' are instinctive, as Prof. Preyer points out, and as Prof. Mark Baldwin has shown. But under normal circumstances the walking of the child is not solely an instinctive activity, acquisition largely co-operates. It is the joint product of instinct and acquisition." Mr. Bain[3] sums

[1] Nature, Vol. XII, pp. 507, 508.
[2] Habit and Instinct, 1896, p. 106.
[3] The Senses and Intellect, 4th Ed., p. 281.

up his view when he says—"the instinctive character of locomotion, so obvious in the inferior animals, is less apparent in ourselves, seeing that the power of walking is not possessed by us until about a year after birth. Nevertheless, there are certain strong presumptions in favor of an original endowment entering into our aptitude for locomotion." The Spencer-Bain theory attempts an explanation along the line of the current biological adaptation. As Prof. Baldwin[1] has summarized the theory—"the organism is endowed with spontaneous movements, a certain spontaneity of action which must be assumed. Certain of these spontaneous movements happen by 'lucky chance' to succeed in bringing the organism into some special adjustment, better exposed, better protection, easier function, etc.; these movements are accompanied by pleasure. The pleasure lingers in the consciousness of the creature in connection with the memory of the particular movement which brought it; and the memory of the pleasure serves to incite the creature to execute the same movements again, whenever the external conditions present themselves. The repetition thus secured serves to fix the new adjustment as a permanent acquisition on the part of the organism." Here we have the assumption of consciousness with pleasure and pain and the power of the creature to associate the stimulus which produced it with the movement which will carry it toward or from the object which produced the sensation. And Bain adds—"Here is assumed the law of pleasure and pain. Pleasure is accompanied by heightened nervous energy, which nervous energy finds its way to the lines of communication that have been opened up by the lucky coincidence." Prof. Baldwin[1] now goes a step farther by what he calls the "Motor Excess," and says that pleasure and pain can be agents of accommodation and development only if the one, pleasure, carries with it the phenomenon of 'motor excess,' the other, pain, the reverse. Then he asks why certain movements which are accidentally more adaptive than others give pleasure. And his answer is, that the movement in itself is not pleasurable, but it is only pleasurable in so far as it gets something for the organism. Something which ministers to its life, that gives it pleasure.

This view assumes, then, that "the organism begins with a susceptibility to certain organic stimulations—food, oxygen, etc.; these when present give pleasure, the pleasure is, physiologically considered, a heightened vitality in the central nuclear processes; this heightened, central vitality issues in a motor excess discharge; from the resulting abundant and varied movements of this excess discharge those are selected which bring

[1] Mental Development, p. 181.

[1] *Ibid*, p. 189.

more of these vital stimulations again; and these finally keep up the vitality of the organism, and by the repeated excess movements, provide for constantly progressive adaptations."

This summary gives us the evolutionary view of movements. Biologically speaking, movement is controlled by the "principle of auto-differentiation." The organism possesses the power of developing in a definite direction and into a definite end product. This power is potentially inherent within the smallest germ. Each living organism carries with it as an essential attribute movement. And movement which is a concomitant of the development of the organ. The so-called "spontaneous movements" of the lower creatures and the human infant are organic. As the nervous system develops, forming co-ordinations of the different centers and the movements become more rhythmic and less spasmodic, as consciousness unfolds, these movements, as any other stimuli produce certain psychic states which can be reproduced at will and the once spontaneous movement becomes voluntary. Observations show also that a successful reproduction of the co-ordinated movements in the infant produce pleasure and it wills to repeat a movement again and again. There is, then, in the child a physiological development as well as a psychic unfolding which bridges the racial and individual experience.

Let us observe the facts as they appear.

Attempts of the Infant to Rise Up.

The first tendency in the child to rise into a sitting posture is manifested in its struggling when it is put down into its crib, after it has been carried in the arms, during the early months of life. There is an attempt to raise the head. This is due to the fact that the primitive segments of the cervical region of the spinal column develop first and precede in growth the remaining parts. The upper parts of the entire body develop earlier and consequently function earlier than the lower parts throughout the early years. The time when the infant can first raise the head varies with different individuals; some are able to hold it erect, and even balance it, at birth, but in general it is about at the the age of two or three months when the head is raised and about four or five months before the muscles are co-ordinated which maintain it erect and keep it from vascillating.

The head of the infant which rolls off the shoulder may fall in any direction; most often, however, it falls forward upon the thorax and rolls toward the side. The muscles of the neck at birth are very small, as has been indicated in the foregoing table, since the neck increases nine times its size at birth.

Movements of the Head.

1. M., 2 mos. Head rolled off in every direction.
2. F., 1 mo. Head falls side and back.
3. F., 3 mos. Head rolls toward front and then toward side.
4. F., 3 mos. Head rolls toward one side.
5. M., birth. Lifted his head without apparent effort on the day of his birth. Seemed able to control the movements of his head from the first.
6. M., 3 days. Tried to raise head but failed. Head fell toward front.
7. M., 1 mo. Head rolled off front, then sideways.

With the ability to raise and balance the head, the muscles of the back, chest and abdomen develop so that the infant may some day surprise its mother or nurse by suddenly stiffening its neck by straining its back and seizing firmly the side of the crib and pulling its body into a sitting posture, or rising on its knees while in its bath. Very frequently this first successful rise is the result of a special and strong stimulus, such as a fit of crying, hearing an unfamiliar sound, etc., and when its feeble efforts are rewarded by success a smile of joy passes over the face of the little one.

Many children are, however, given the suggestion to rise in a sitting position by grasping a parent's extended fingers and are then pulled erect. Miss Shinn observed that as early as the seventh week, when the mother held the hands of the child in wiping her after her bath, there were slight muscular contractions, though with no intent to pull herself up, as her mother had tried to develop it by giving her a finger and pulling. When the child was three months old, she succeeded in rising up by the aid of the fingers, but immediately tipped over sideways. After that she tried twenty-five times in succession to lift herself by her abdominal muscles, but could only lift her head and shoulders. She was then stopped as she showed discouragement. The common method employed by children in sitting up when placed upon the floor on their backs where they cannot pull themselves up by their hands is—by first rolling over upon the stomach; they then rise upon the hands and knees, turn sidewise in a half reclining, half sitting position, supporting the body with one hand and finally raise the trunk into a sitting position. A rather peculiar manner is seen in Miss Shinn's niece. The child first rose to her hands and knees, then separated the knees and lifted herself backward into a sitting position, landing the child with its legs spread wide before turning out at each knee in a right angle. This exceptional sitting position was invariably assumed. The usual position for children is the simian—in which the legs are extended forward with the soles turned toward each other. After such exercises, repeated daily, children soon learn the

possibility of sitting erect and are not content to lie down when not asleep.

1. F., 4 mos. Baby could not raise itself when lying down. One day it was angry because it wanted to be taken from its cradle. It stiffened its neck, seemed to exert all the muscles of its chest and abdomen, and after falling back two or three times succeeded in raising its body into a sitting position.

2. F., 2 mos. When Mary first began to sit up she would stiffen her neck and then her back and try to balance herself in that manner.

3. M., 3 mos. First raised its head like a turtle.

4. M., 4 mos. Baby first raised its head again and again until it could raise its head and back.

5. M., 4 mos. Tried to sit up when lying on its back, but could only succeed in raising the head from the pillow. After repeated efforts it got over on its side, then it pushed itself up and rested on its arms in a half reclining position.

6. F., 1 mo. Helen tried to sit up by first taking hold of the side of the crib and then tried to pull herself up.

7. F., 2 yrs. Tried to sit up by raising her head up as far as possible without using her hands.

8. F., 2 mos. This child while lying on its back would raise its feet and head, the head in its effort to rise would bob from side to side.

9. F., 4 mos. In trying to sit up the child will first raise its head, then its back, followed by frantic efforts to rise farther.

10. M., 2 mos. In trying to sit up the baby would first raise its head, then try to pull up the body with all its might.

11. F., 1½ mos. I have seen Mary, when lying in her crib or carriage, take hold of it with her hands and try to pull herself up.

12. M. The baby was lying in its bed; it took hold of the side with its hands and succeeded in raising its head up. It would then lie back and rest awhile and soon repeat the process.

After the muscles of the neck and trunk have developed sufficiently to raise the head, the child must still learn to coordinate their movements and tension, to balance it upon the trunk. The head at first bobs and jerks from side to side, forward and back, under which conditions the infant manifests not a little interest mingled with anxiety and determination. Unexpectedly, however, the head takes a sudden roll forward and sidewise through a great part of the arc, regardless of consequences. There are as yet no compensation movements to protect it. The only way in which nature has favored the infant against serious bumps at this time is in allowing the muscles which raise the head to precede the muscles of the trunk in development. The infant makes no attempt to save its head from injury until later when it can raise its body. Then after repeated experiences are the movements of falling and the sudden stop associated, and compensation movements manifest themselves. From the returns and observations, it appears that there are three different means employed of saving the head from bumps. First, a twitching of the eye; second, turning the head in another direction to oppose the fall; and third, putting out the hand to secure the head or intervene between

it and the obstacle, thereby making a softer surface to strike. The last seems to be by far the most common.

1. M., 5 mos. Baby does'n't know enough to keep his head from bumping, just falls over and bumps.
2. F., 8 mos. First made no attempt to save the head; later it used the hands to shield the head and tried to fall on the hands.
3. M., 2 mos. If the head rolled off, or even if you lowered him quickly, he would shut his eyes and throw his hands forward to save himself.
4. M., 7 mos. Put his hand on surface against which his head might fall to save it from the bump.
5. F., 6 mos. The child holds on to the pillow with the hands to save its head from bumps.
6. F., 3 mos. After a few bumps she would put up her hand.
7. M., 4 mos. Simply lets the head bump.

In the same manner, it requires several weeks for the muscles of the trunk to develop sufficiently to balance the body in the sitting posture.

The returns show that the body falls over forward and toward either side, but usually toward the front and toward the right side. This fact shows that the legs at this time already play a little part in supporting the body as braces. In case the body falls toward the right side and a little forward we can probably see the influence of the prenatal position of the right leg, which is often raised and extended across the body, so that the position of the left leg upon the floor more firmly than the right may throw the body as it falls forward toward the right. The movements of the hand are almost entirely directed forward. The baby reaches forward, in case there is an object at the side which it wants, the body is turned to face the object, then extends its hand. In case an attempt to reach sideways is made the body is sure to fall in that direction. This shows conclusively that the co-ordination of movements takes place along a certain line and is subject to a law of development which is much influenced by prenatal conditions. At about the seventh to the ninth month the normal child has sufficient control of its muscles to enable it to sit erect without being held or fear of falling over. It cannot yet move nor does it attempt to do so. Dr. Rotch[1] says of this period of child growth "that as long as the infant
happy in the prone position, whether in the nursery
is better for it to be kept in this position. When it
n during the first year the back should be care-
by a pillow." The hospital reports show that
arrying children, as well as the means employed
n to sit up, results in serious spinal deformities,
developed muscles have a tendency to allow the
ateral and posterior curvature.

ediatrics.

1. F., 2 yrs. The baby would fall toward the front.

2. M., 9½ mos. The baby would fall toward the front and side, but more frequently toward the right side.

3. M., 5 mos. The child was propped up in a horse collar on the floor, it then would fall forward on its face.

4. M., 1 mo. The child was propped up with pillows, he would then try to lift his head and look around, but his head would roll off sideways. He falls toward the front and always when about to go puts out his hands and closes his eyes.

5. F., 6 mos. The baby was most apt to tip over toward the left side.

6. F., 4 mos. Mabel was taught to sit up alone by being put in a sewing machine top with pillows and blankets around her.

7. M., 2 mos. Baby was most liable to fall toward the right side.

8. M., 1 mo. The baby falls forward and almost always toward the right.

Rolling Over and Creeping.

Dr. Ploss says "the child will learn to walk by its own efforts, if, at the time it feels the increasing strength of its muscles, it is allowed to exercise its limbs upon the floor." At first very feebly it sits erect, then follow its desires to change position and reach for or move toward distant objects by getting upon its hands and knees and creeping or hitchiug along with its feet to the desired spot. Creeping or hitching is then a necessary step to walking.

The study of creeping as it appears in this chapter is based upon the returns of observations made upon 150 different children representing those of American, English, German and Irish parentage. As creeping and walking are entirely voluntary movements the individuality of the child appears very markedly.

The returns show that early in life, sometimes by the third month, the reflexes of the legs become more or less co-ordinated into differentiated rhythmic movements, which are simply alternating leg movements. They may be forward and backward or the reverse, rarely sideways. These rhythmic kicks may very early be stimulated by touching the soles of the feet to a coverlet or floor. Some children will amuse themselves for half an hour by simply repeating these alternating movements. Prof. Baldwin noticed in one of his children that alternating movements were backward but that creeping had a tendency to correct them.

At seven months the well, strong child will enjoy standing on its feet if supported. It will straighten its legs and press its feet against a resisting surface. It will jump and kick vigorously.

M., 10 mos. Baby would push its feet against the crib or pound its feet on the floor when lying down with much enjoyment.

M., 7 mos. When placed so that his feet could touch a flat surface, he would put down his feet as if trying to walk. Would also push his feet against a person's lap in standing up.

F., 3 mos. Pushed with her feet against one's body.

M., 4-6 mos. Lay on the floor on his back and kicked for 20 minutes with much apparent enjoyment.

F., 9 mos. In trying to stand, she would jump up and down on her mother's lap, and place one foot on the top of the other.

M., 6 mos. As soon as he felt his toes touching he would dance up and down. His little back would stiffen and his leg would straighten out.

The manner of turning over on the belly, preparatory to creeping, varies with different children. Some thoroughly enjoy lying on the abdomen, while others do not, one observer states that she could always stop a child from crying by placing it, when very young, across her knees. This position may have relieved a disturbed stomach or other visceral ailment. Other children may roll over accidentally and find that they can apply their hands to better advantage than when lying on their backs. Other children do not enjoy lying in a prone position, especially after they have gained sufficient strength to sit erect. They lean forward, sidewise, and turn part way, half-reclining, half-sitting. By irregular movements they assume a variety of positions. The majority of children, however, will, when placed upon the floor, after they have gained sufficient strength, roll over on the abdomen and pat the floor with the palms of their hands. When this position has been gained, children will soon learn to raise the body with their hands. One observer remarks—"when Eva first attempted to support her body with her hands she would put her little hands flat on the floor and with a great strain try to raise her body. Her first efforts failed; soon she could raise the body, but not sufficiently to straighten her elbows, and after a few moments her strength gave way and the body fell heavily."

The different means employed by children in turning over on the belly vary from the purely accidental to those which appear to be voluntary. Some roll over while trying to reach forward for an object and often manifest extreme surprise at the position, or they cry, perhaps because of the shock. Others roll over upon the side after much wiggling, and then by a sudden movement of the hand or leg roll over, or they may throw one or both legs over, thus carrying the body over upon ·he side. Still other children turn over from the sitting posi- ›n. They first turn over on the side then upon the belly. ıe same method is usually employed by a child which was st successful, no matter how laborious.

Rolling Over on the Abdomen. Raises the head a little and a cor- ponding movement of the legs—then rolls over with one arm lerneath it. After repeated trials this arm was drawn out.

hild was lying on its back, it rolled over upon its side with one under it. In its effort to get its hand out it rolled over on its . It first placed arms out at full length upon the floor.

M., 10 mos. In making an attempt to roll over he would raise his head and roll over on his side as far as possible and strain as hard as he could. He would, at times, be unsuccessful and cry.

M., 9 mos. When the child reached for something he toppled over, then in trying to get up again he props himself up, and in this manner acquired the habit of creeping.

M., 10. Put one hand on the floor and held one leg still while it threw the other over, carrying the body to the side.

F., 8 mos. When sitting on the floor, she would roll over on her side, then turn over on her belly and kick.

F., 9 mos. Put hands over to one side then turned the body after.

Creeping. From this position of sitting one of the various forms of creeping is easily employed. A study of 150 children (males and females equally divided), shows that 60% crept while of the remaining, 30% moved along by hitching, 7% by rolling, 3% by crawling, swimming, or some other means peculiar to the individual. [1]Fifty % of the creepers moved forward on their hands and knees, moving their limbs on the opposite corners of the body together. [1]Twenty % moved forward on their hands and knees but moved the limbs on the same side of the body at the same time as in pacing. Nine % walked on their hands and feet with the limbs on the opposite corners of the body moving together, except one little girl moved the limbs on the same side together. One little boy planted the feet out aside of the tracks of his hands. Twelve % (7 males and 4 females) walked on their hands and dragged the body and legs, and 6% (3 males and 2 females) crept backwards. One used his hands only in pushing the body back to the desired spot. The remaining 3% had movements which were distinct from any other or combinations of other movements of creeping, such as creeping on the hands and knees, the hands alternating and the knees moving together as in jumping; creeping by the use of both arms and one leg while dragging the other leg; or by the use of only one arm and one leg.

M., 12 mos. In creeping he used first one hand then the other, then drew up both legs together.

This child goes along with one leg out straight behind, creeps on its two hands and one knee.

M., 6 mos. He crept in the ordinary way, using the l. a. and l. l., then r. a. and r. l.

F., 6 mos. Crept on both hands and with right foot, dragging the left.

F., 7 mos. When D— sits on the floor she goes over to the right, raises herself with her right hand, then gets on her hands and knees and creeps around, making a great noise for a small child.

M., 6½ mos. James used to creep in a very peculiar manner. He only used one arm and one leg. He would rest on the other side of the body, but never use those limbs in creeping.

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[1] Boys and girls equally divided

F., 10 mos. D— began creeping at the age of ten months; she moved the r. a. and l. l., then the l. a. and r. l.

F., 10 mos. Lucy first began to creep, then walked on her hands and feet.

F., 6 mos. Walked on hands and toes.

F., 11 mos. The baby got on its stomach and with its two hands endeavored to move along, occasionally kicking slightly with its lower limbs. In moving the limbs acted alternately. One day evidently the child could not creep, in this way, fast enough to suit herself, so she very quickly turned round and by the use of her hands and by kicking her feet she pulled herself backwards.

M. The child is very fat. He does not creep on his hands and knees, but sits square down on the floor and by the aid of his hands slides along.

M., 5 mos. He would put his hands on the floor and then slide his feet out from under him toward the back.

M., 6 mos. To get along on the floor, he would sit on his right leg and rest on his right hand, dragging his left leg after him and using his left hand for propulsion.

M., 6 mos. He pushed himself backward with his hands.

The baby lay on its stomach and used her arms half bent to drag herself along.

M., 9 mos. Little Frank, in trying to move about the room, would place his hands flat on the floor just as far in front of him as he could possibly reach, then bear his weight on them and lift the front part of the body off the floor, then he would give a spring and throw his body forward. His little twin sister, Marjory, would lie almost flat on the floor and wriggle along like a worm, first to one side then to the other, with her hands in front of her which pulled her along.

Hitching. The next most common means of infant locomotion is the so-called hitching. The returns show that 30% of the whole number of children observed progress in this manner. The child does not turn over on its belly but moves in a sitting position. The movement is usually preceded by reaching toward an object desired which tends to carry the upper part of the body forward; this forward movement of the body produces its natural converse, that of drawing the feet toward the body or bracing them upon the floor; this may draw the entire body forward. Some of the variations in hitching are such as sitting perfectly erect and pulling the body forward with both heels; pushing the body along with both heels and sliding the feet forward; sitting on the left hip and using the right leg and left arm to move the body forward; using the right leg and arm to move the body and drag the other leg after; using both
[illegible] d both hands, the feet to pull and the hands to push the
[illegible] rking movements of the back which carry the body
[illegible] or simply twisting along in a sitting position without
[illegible] either limbs.

[illegible] sat upright on the floor and hitched himself along with-
[illegible] his hands. Another baby sat on the floor and used only

[illegible] s. Little Nannie would sit straight up on the floor and
[illegible] tting her hands to the floor, work along as fast as a person

would walk. She did not make much effort and her parents often wondered how she could do it.

F., 9 mos. Sadie hitched along using one (right) hand and foot.

F., 12 mos. Child was very backward in creeping and when she did begin she pushed herself along by her hips, first on one side, then on the other.

F., 14 mos. Violet never crept. When 14 months old, she moved around by sitting on the floor and using one leg to help her along over the floor. She put her leg and foot forward and then seemed to steady them and draw her body along.

F., 8 mos. Sat up straight and hitch along. She never crept, but after this stage learned to walk.

F., 9½ mos. Would sit down on the floor and push herself backward, moving a little from one side to the other. Could move faster in this manner than if she had crept.

M., 10 mos. This child would hitch along. It would have its left foot under its right. Its right knee was erect with its hands resting upon it.

Rolling. Rolling is an occasional form of child locomotion. 7% of the whole number observed rolled over and over until they arrived at the place desired. One peculiarity in this rather exceptional manner appears in the apparent deliberation of the child just before setting out as if to decide just what and how to do it, but after several attempts he becomes very proficient in its movements.

Occasionally we find a child which can creep quite well but rather slowly. But if it is in a hurry it will abandon this manner and lie down and roll over and over, thus going much faster. In studying the early creeping and rolling movements of her niece, Miss Shinn thinks that the child's skirts interfered considerably with the attempts to creep which the grandmother had attempted to teach the child but were abandoned in favor of rolling. She then concludes that "without the hampering influence of long skirts and the practice of keeping babies off the floor, this primitive quadrupedal movement would appear much earlier, and play a larger part in infant activities, than it does. If it preceded securely balanced sitting, the less natural and less useful hitching would never appear as a substitute." This conclusion is not warranted by the studies made upon the babies of primitive people who are not hampered by skirts or cold floors, yet they prefer hitching to creeping.

Exceptional Movements. Among the 3% of the exceptional movements are seen the following:—Crawling like a worm upon the belly with the hands and feet close but using them very little; swimming movements, the hands moving at the sides with feet kicking; moving backwards on the buttocks and elbows, the head occasionally striking the floor wearing a bald spot on the back of it; crawling upon the belly using hands and abdominal muscles to throw the body forward with considerable force; wriggling from side to side or forward and back-

ward on the buttocks without the use of the limbs; and attempting to move forward by swimming movements but thereby moving backward. In these returns the movements were recorded according to the sexes, but they distribute themselves about equally, so that it is not necessary to draw a further distinction.

Rolling.

M. This child first moved from place to place by rolling.

F., 9 mos. At the age of nine months Emily started to roll over and over across the floor. She would first raise her hands and feet to give herself a start, then roll anywhere she wished to go.

M., 8 mos. Walton made most progress when he rolled on his right side.

Hopping.

M. Harold went along like a frog. Laying palms of hands on the floor, then with a little jerk of his body would land on his knees. He would then begin again with his hands and repeat the same process. He progressed quite rapidly considering his method.

Swimming.

M., 9 mos. Carlyle creeps in a sort of half swimming manner. He lies on the floor in this position, his arms and legs are partly bent. He pulls himself along by using the arms alternately.

F., 8½ mos. Lies very flat on the floor with upper part of the body raised slightly. Both arms move outward at the same time. She then puts her hands flat on the floor and her legs move alternately. Then she brings the hands forward, the legs move, the hands move outward and so on. She does not get along very well and seems to try to move forward though moves backward instead. The child would simply wriggle and twist irregularly until he came to the object wanted.

M., 10 mos. Holt was sitting on the floor and near him was a chair, on which there was a bright apple. He looked at it a moment then wriggled over to the chair and taking hold of round by round he drew himself up.

Climbing. Climbing is one of the early impulses of children. Indeed, some of them manifest this desire as soon as they begin to creep. The desire to climb seems to arise in a desire to explore every available spot and practice every known movement. As arms and hands precede the legs in functional development, children may be seen pulling their bodies up alongside a chair, a table-leg or other object even before their legs are able to bear the weight of the body. An observer says of a little girl ten months old—"this child could climb upon chairs, upon the table and upon the refrigerator before she could walk. She had several falls, but nothing would stop this desire to climb until she learned to walk, then it seemed to pass away." There is a desire in the child to get up higher. This impulse leads it not only to draw the body into a standing position but also to get to the top of every attainable object. In the case cited, the desire to climb was inhibited by the ability to walk. This is not common in children, as the ability to walk simply opens

a wider range for their activity and thus favors it by an increased muscular vigor. Fear of high places or of falling is not at all common in the first acts of climbing. It is only after they have had several calamitous experiences that fear in some case may restrain this activity.

As the child grows in strength, the skill it acquires as a climber is quite remarkable at times, from chairs, tables and other furniture to fences, gates, ladders and trees. It tries an experiment continually to get into some new position and relation with an object with which it is engaged. One little fellow tried, after climbing to the highest part of a chair, to put himself through every open space in it. It was a pure love of climbing that engaged his attention for a half an hour.

M., 3 yrs. Everett is very fond of climbing up in and down out of wagons. He does it just for the sake of climbing. He always gets down backwards and never allows any one to help him.

F., 11 yrs. When I was small I climbed on the table set for tea and tipped it over. I was punished and much frightened, but it did not restrain my desire for climbing. When I went out into the yard, I climbed upon the top of a pig pen and fell in. The pig ate my hat and tore my dress, but I was rescued. The next day I was found on top of the same pen. I was afraid of the pig inside but I wanted to climb.

M., 2 yrs. At the age of 1½ years he was climbing all the time on chairs, high chairs, step ladders, etc. It was easier for him to get up than to get down.

F., 4 yrs. I had a great desire to climb up into the trees in the orchard. Mamma was often frightened to see me so high in a cherry tree. The higher I could get the better I liked it.

M., 14 mos. When John learned to walk he wanted to climb. One day he got on the table and broke his arm. After it had only been dressed one half hour, he got up on the chair near the window and broke the glass.

F., 10 mos. This child, before she could walk, would climb upon chairs and on the table. She climbed upon the refrigerator from a chair. She had several falls but nothing would stop her until she learned to walk, then her love for climbing seemed to pass away.

M., 18 mos. The door was open so that the child got out. When his mother found him he was climbing upon the horse trough.

M., 2 yrs. Wilbur would run away and climb upon every object he could find. Into the most dangerous places.

M., 14 mos. This child climbed into a chair, then upon the sewing machine, then on a desk a little higher.

Children first learn to get off of a bed or a chair and to go up and down stairs after they have learned to creep. It appears as a desire to follow a grown person, or a desire to explore together with the desire to climb. In getting off a bed the greater number of children creep or hitch along to the edge, then turn over on the belly, seize the bed clothes firmly with their hands and slide the body off the edge, holding with their hands, until the feet touch the floor, or drop heavily. Others, though few in numbers, slide off head foremost, by putting the

hands upon the floor and drawing the body after. One case was noted where a little girl rolled to the edge of the bed and then rolled off upon the floor, falling heavily; she repeated the process two or three times, but found it too painful, and after that remained upon the bed until some one took her down.

F. In getting off a bed she would lie on her stomach and keep backing down until her feet reached the floor.

F. She got off a bed by hitching over to the edge and then turning over on her face, she would grasp the clothes with both hands, slide both legs off, and then when nearly down let herself drop.

F., 2 years. If she was on a chair, or a bed, and wanted to get down, she would slide off on her stomach, if she couldn't reach the floor, she would let loose and drop down the rest of the way, regardless of bumps.

M., 2 yrs. In getting off a bed he first puts his hands on the floor and slides the rest of his body after. He can walk well.

F., 9 mos. If baby wanted to get out of the bed, she would roll near the edge and then roll out upon the floor; she tried this several times and found that the bump was too great to endure.

In going up and down stairs, of the different ways employed the most common is creeping, in which the child goes up on its hands and knees or hands and feet; in coming down it will creep backwards, putting down its feet first on the next lower step. A child, in both ascending and descending a flight of stairs, will often turn to see how far up it has gone. Another manner of climbing stairs is that of creeping up and then turn and sit down on the step and slide down to the next one below, using the hands to steady the body. Some children go up stairs by drawing themselves up alongside of the banister with their hands and step up with their feet. This is a more mature method and is only employed by those children who have already learned to walk. An exception to the general manner is found in a little boy who went down stairs head foremost. He put his hands on the step and then let the body slide down after him.

F. In going up stairs she would place both hands on a step, then bring up both feet to the next lower step, and so proceed. In going down she would sit on a step and slide down to the next lower.

M., 14 mos. Soon after Harold learned to walk he began to go up and down stairs by holding on to the banister.

The child goes up stairs on its hands and feet and backs down in the same manner.

F., 2 yrs. In coming down stairs, Dorothy would sit down on a step, straighten out her body and slide down to the next one. In going up she would put one foot on the step above and taking hold of the railing would lift herself up until both feet were on the step.

15 mos. It placed the left foot on the lower step and brought down the right knee on the level with it; the child could hardly creep, but in this manner it learned to walk.

13 mos. This child often sits on a step and then slides down to the next lower, using the hands to keep from tipping forward.

M., 21 mos. Everett took hold of the banister and put one foot upon

the step, then drew the body and the other foot up. He rested awhile and repeated the act on the next step.

M., 2 yrs. Thomas always goes down stairs head first; he first puts his hands on the step and slides the body down behind him.

F., 18 mos. In going down stairs she laid flat on her stomach with her right leg and foot bent up acting like a rudder, the left leg extended straight from the body, and the hands rested on the step above as she descended. In this way she slid down the stairs as fast as one could run down. She crawled up on her hands and knees.

Rising into the Standing Position.

The child has learned to sit up by grasping a person's extended fingers and is thus pulled up. It will seize every available object within its reach. After it has learned to creep or hitch, and in some instances while still sitting in the lap, it will seize the extended fingers or other objects and brace its feet so that it may be raised into a standing position. [1]Mrs. W. S. Hall observed a child in the thirty-eighth week; he stretched his body and right hand toward his baby-carriage, within reach, and seized the handle firmly which he drew near enough to grasp with both hands. He then braced his feet against his mother's lap and pulled himself up, swaying back and forth, alternately pushing and pulling the carriage. He also pulled himself up by the extended fingers of the mother and remained standing a minute, when he was laid back upon the floor to rise again, this time standing two minutes. Several weeks later, at twelve months, he was able to rise by the aid of a chair, and remain standing for five minutes, holding to the chair with one hand while playing with the other. Some children delay standing if they are not given the initial suggestion, as was seen in Mrs. Hall's child, but are content to creep, until suddenly they will be seen rising up in the center of a room without support; first, from the creeping position to the hands and feet, they raise one hand carefully and place it upon the knee as a brace, and finally, with considerable unsteadiness, raise the body erect.

M., 12 mos. One day Melbourne was creeping on the floor when he saw something on a chair. He did not creep over to the chair, but stood upon his hands and feet, then raised one hand from the floor and soon raised himself up. He stood a moment as if to balance himself, then took two or three steps. He then took hold of the chair, got the object he wanted and sat down. After this he most always got up from the floor in this manner. This attempt was unconscious, for after he obtained the object he sat down and did not seem to realize that he had done anything unusual. It made his breath come faster.

F., 10 mos. Daisy, when learning to walk, simply rose from the floor, stood up and walked away. This was the first time she had walked at all.

F., 9 mos. Francisca never crept. One day she was sitting on the

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[1] Child Study Monthly, Dec., 1896, p. 398.

floor and suddenly got up and started to walk. After walking awhile she fell; she laughed, got up again and started off.

M., 1 yr. Frederick was sitting on the floor. His mother came near him when he seized her dress tightly and pulled himself upon his feet. He stood for a moment and would have fallen had his mother not held him.

Standing. The child first stands resting its partial weight upon its legs when supported in its mother's or nurse's lap. The body is inclined forward, the knees and hips are bent. As the muscles of the back and legs develop the limbs are brought into line with the trunk, the spine assumes its double curvature, the child stands supported only by steadying itself near a chair or near the wall. The age at which children first are able to bear their entire weight unsupported upon their limbs varies from seven to sixteen months, the large number falling between ten and twelve months. Frequently, children who are not encouraged to rest their weight upon their feet do not show an early desire to do so. Mrs. W. S. Hall observed that the child braced himself in a standing position on the 135th day (4½ months). After that he was permitted to bear a part of his weight in standing when he desired. In this position children soon learn to alternate the use of their hands in supporting the body near a chair and may remain upon their feet for a half an hour at a time moving the hands and feet continually. When children arrive at this stage of development, there is a constant desire to remain upon the floor. One observer remarks that there was a great unwillingness to be taken up from the floor for meals, the child tried to take its food while standing.

The child learns to stand in the mother's lap and with her assistance, later, it learns to stand by means of a chair or wall. The first efforts were unconscious.

M., 8 mos. The first time Albert stood alone he was put near his carriage and had nothing to support him but the handles of the carriage. He was unconscious of it.

F. Edna would get a hold of the leg of a chair and pull herself up, sometimes making several attempts before succeeding. At times these efforts appeared entirely unconscious, at other times conscious. Her first steps were taken around a chair, then she went from one chair to another.

F., 16 mos. Nellie came and took hold of my dress and pulled herself up and stood for some time. I took her up, but she objected to this and let herself down and crept away. This was the first time it had been noticed that she stood. It seemed to be unconscious. Two weeks later she stood alone in the middle of the floor laughing and waving her hand. She received a severe bump which made her afraid to rise up unsupported until she had learned to walk.

M. Leon was creeping on the floor, and catching hold of the rounds of a chair he pulled himself up. He stood up because he wanted to, as there was no inducement offered. He was very proud of it. A fall which he received made him timid.

M., 1 yr. Marvin's first steps were beside a sofa. They were unconscious, for as soon as he realized what he was doing he fell.

F., 10 mos. The first effort Barbara made to stand was near her mother's knee. It seemed unconscious. Her breath seemed to be shorter.

F., 8½ mos. Alice's first attempt to stand was when she drew herself up by holding on to the table legs.

MOVEMENTS ANTICIPATING WALKING.

For the first three months of the child's life the movements of the limbs are the so-called instinctive, reflex or organic. The limbs are bent most at the shoulder and hip joints. The large supra-spinatus and the infra-spinatus muscles of the shoulders are functioned at birth, making possible this movement of the arms, which is not in the same plane with a line parallel with the axis of the body, but varying about 20° toward the body from this plane, causing the hands to move mouthward rather than forward. The intentional flexion, as Mrs. W. S. Hall has observed, develops earlier than the corresponding extension. The child could put his thumb into his mouth, at will, but could not remove it. In the leg, the greatest amount of the early movement is caused by the flexion and extension of the psoas, iliacus and pectineus, which lie in front of the joint and the gluteus maximus and medius muscles which draw the leg into line with the trunk. At three months, the child of normal development is, without doubt, conscious of these limb movements which are gradually becoming more rhythmic and co-ordinated. They give him considerable pleasure, which exists in the consciousness of an ability to do, as observers think, rather than in the exercise itself. The arms and legs at times are moving quite in unison. Soon after this period, there appears the response to a stimulus applied to the soles of the feet, the tendency to push. When supported erect, the desire to jump, until the standing position is acquired, after which comes the alternating movement of the legs as above mentioned.

Walking. From the standing position it is a short step to walking. The first step is usually taken alongside of a chair or the wall. The legs have already learned the alternating movements by creeping and jumping in the lap or kicking. Very frequently the first steps are taken by lifting the feet and placing them again in the same tracks. Gradually the body moves and the legs are brought forward or backward to maintain the equilibrium. The chair may accidently move and the child follow it by taking a step. Then follow the movements from one object to another placed a short distance apart, or walking beside a person holding firmly to the hand or dress. One little girl at nine months of age at first clutched a person's dress in walking, then she seized the scallops of her embroidery on the bottom of her own dress and walked off bravely, feeling

perfectly safe. Frequently a child will not use a chair, wall or other object at all, it will rise up in the centre of a room and steady itself, then take several steps unsupported.

Some children walk by pushing a chair about a room, thus continually steadying the body; others are assisted by their parents, who support the weight of the body, allowing the feet to touch the floor and the legs to move. When left to themselves after this exercise, they will attempt the movement alone, and at times will succeed quite as well. At first children are afraid to let go their hold of a support, unless some especially attractive object or considerable encouragement from the attendants makes them forget the bodily state and they totter along unconsciously. After confidence is acquired, they reluctantly return to creeping, and prefer walking even to riding.

Children, as a rule, walk "pigeon toed," and it is only by a process of growth that the feet assume a proper angle and the legs become straight from the "bowed" condition at birth.

M., 11 mos. Albert was playing with the front part of the carriage when suddenly he began to walk, being unconscious of what he was doing.

F. She could stand alone near a chair or wall. The first steps were taken while leaning against the wall. Her mamma stood a few steps off with her outstretched arms coaxing the child to come to her. She ran into her mother's arms and repeatedly did so until she could walk alone.

F. Her first steps alone were in going from a chair to a person's arms a yard distant. She tried it very timidly at first and fell several times in the attempt. At last she succeeded and was so perfectly delighted to think that she could walk without help.

M., 11 mos. Harold walked toward a little dog which he had not seen before. I do not believe he was conscious of what he was doing for he was so intent on the dog. After this he walked so much that he could not rest at night.

M. Leon's first steps were taken between two chairs. After he had learned to walk, he would tire himself out so as to be sick.

M., 10 mos. Jack was creeping one day, when he came to his chair he stopped suddenly and looked up. By the aid of his arms he pulled himself up slowly and carefully on his feet (all during the process his tongue was out), at last one hand reached the seat of the chair and Jack was on his feet. He began to spring and laugh then turned to his mother, who was opposite, and made three steps to her knee, balancing himself by holding out both arms. He was so well pleased that for several days he would always go to the same chair and begin his walk.

F., 9 mos. Alice's first steps were taken when she was 9 months old. She walked by pushing a chair around the room. At times she would leave the chair and take a few steps toward her mother who stood near.

M., 10 mos. Frank could stand by holding fast to chairs, table legs, etc., but he had not walked. One day while he stood near a chair, his mother invited him to come to her. He started and walked all the way across the room to her. He was very proud of this feat, although he did not walk alone again for two weeks, during which time he clung to the chairs and the walls.

F., 11 mos. The first unsupported steps were taken between two persons sitting about four feet apart, they were quite conscious, being the

result of considerable coaxing. The steps were carefully taken, the body settling firmly at each step, the arms were extended. There was a decided leaning forward of the body with the right side a little forward of the left. She has only walked when asked to do so.

Consciousness of Standing and Walking.

Several questions will arise at this point which it will be well to consider. First—are these first efforts to change the verticality of the body in standing and walking, conscious efforts on the part of children? Second—what are the effects of standing and walking upon the physical organism? Third—how do they effect the psychic life?

Let us consider the questions in the order in which they arise. First—are the first efforts to stand and walk conscious? The writer realizes the difficulties into which this question at once plunges one, since it involves the whole question of the relation of consciousness to life.

The returns in answer to this question are not at all unanimous, since they confirm both the consciousness as well as the unconsciousness of the movement. A careful study of them, however, does not reveal such a diversity, as it shows that the observations were made at different stages of the child's development and upon different children. Let us consider several concrete cases. A boy nineteen months old, who had never stood alone, while sitting upon the floor saw a fly on the wall. He took hold of the table leg near him and rose on his knees, he then stood that way for a time, then by degrees he rose to his feet. When he was up he looked for the fly which had gone. He sat down with a thump and did not try to stand again for five months. A little girl, one year old, saw some candy in a chair, she crept to the chair, then climbed up and stood unsupported. As soon as she seemed to think of what she was doing she sat down. Her breath then came fast. Another child saw his mother handling his red dressed doll; he crept to her, pulled himself up and stood. The observer believes that he was entirely unconscious of all else but the red dress of his doll.

Another example is given by Professor Kirkpatrick of Supt. Hall's little girl. She was, in all respects, a normal child, but unable to walk at seventeen month of age. One day the father came home to dinner and placed his cuffs upon a table and laid down to rest. The child, seeing the cuffs, crept to the table, pulled herself up by the leg of the table, took the cuffs, one at a time, and slipped them over her wrists, standing unsupported while doing it. She then stood looking very much interested in the cuffs. Then, to the great surprise of the father, she walked with great confidence with a pleased expression on her face. She also ran, continuing this for ten minutes, then sat

down and rested, after which she arose alone and walked again. Without the cuffs, however, she could not be induced to take a single step. She was given an old pair of cuffs and she seemed greatly delighted; she walked and ran as before. She used the cuffs for two days, after which she walked without them and did not revert to crawling.

There are many other observations which might be cited to show that the evidence is against the popular thought that the child must learn to make these movements. That he must, from the infinite number of possible movements, select, from the four hundred muscles which move, the right muscles and the correct combinations of these to enable him to move. This task would be too enormous for the space of a year or fifteen months.

Another view is that walking is entirely instinctive and that it is inherited as in the young animal; but, as Prof. Bain says, the mechanism at birth is not completed. There are children who walk the very first time they make the attempt, so that this view has much in favor of it. But the walking in a large number of children will not support this theory by the evidence it gives.

We are then given a third view, that often held by psychologists and physiologists. This theory sets forth the play between the unconscious and the conscious elements.

Common observation shows that the reflex movements of early life are a natural concomitant of the organism and become established in consciousness, and consciousness in turn assumes a directive control over these organic movements and builds up complex groups, which in turn make possible more complicated movements. Very early in the infant's life it can be seen attempting to imitate a movement which it has seen, or when it is intensely interested in the movement of a person its body will respond very markedly. This does not seem to be a matter of chance, but there is undoubtedly physiologically a close connection between the visual and the motor centers. This physiological part determines the direction of the impulse.

A child sees an object, he grasps it. The visual sensations call into play the movements of the proper muscles. The conscious element is the visual image, the motor element is unconscious.

I am practicing to throw a ball at a target. The attention is focused upon a spot in the center of the target, that alone is in consciousness, the movements of the arms, the position of the body and legs all adjust themselves unconsciously to meet the impulse from the sensory center. The same is seen in the case of a child's walking. He has a visual impression, a fly, a red dress or what not, this is sufficient to call into action the motor apparatus at the time when it is developed sufficiently.

The close relationship existing between the sensory and the motor centers makes possible even new co-ordinations with the attention directed toward the former and surrendering wholly to the unconscious the motor element.

Let us suppose the child sitting upon the floor; he is able to creep but does not take any steps. He sees a fly upon the wall. A visual impulse comes to him, it is strong enough to absorb his attention, and movement results. The functional development has advanced sufficiently that the co-ordination may be made. The child rises up and stands. Or another child's attention is entirely concentrated upon the getting of the cuffs, putting them on, etc. The attention is not, in either of these cases, upon the movements, for when the visual image is removed, the motor image arises, the newness of the situation at once destroys the co-ordination, and the child sits down. The direction of the attention toward the movement disturbs co-ordinations of movements rather than favors them in children as well as in adults. But there is another element which enters in. Many children, before they are strong enough to walk are held upon the floor or table with their feet touching which no doubt suggests walking, they are urged and guided and led. Here the conscious states no doubt precede the functional, since we can see such children trying to repeat the position and movements which have been suggested to them in this manner by their parents or nurses. This is, however, reversing the biological order of development.

F., 13 mos. Gladys pulled herself up by her mother's dress, after she became conscious of her power she felt very proud of it. Her breath was short from the effort of it.

M. Tommie's mother had a doll dressed in a bright red dress in her hand. Tommie was sitting on the floor near his mother when he became so interested in this doll that he pulled himself up by her dress and tried to reach it. I think he was entirely unconscious of what he was doing, except that he saw the doll. After he had got on his feet he stood for a few seconds.

F., 24 mos. Alice first tried to stand by pulling herself up by chairs, etc. I think the first efforts were unconscious for she usually made them while trying to reach something. After she had made her first successful attempt she looked around to see if anybody had noticed her.

F., 1 yr. Margaret was sitting on the floor beside a chair, she tried to stand by taking hold of the chair, but failed. She made several attempts before she succeeded. Finally after she had stood for a few moments she looked around to see if any one was seeing her and smiled. I think she was conscious of the act.

M., 11 mos. John was placed in a wash-tub with cushions in the bottom. He reached up and placed his hands on the side of the tub and then tried to stand on his feet. At first he was on his knees then stood on one foot. He would fall, but not be discouraged. He worked fully five minutes trying to get on his feet, his face was moving and his breath came quickly. After he succeeded in standing up he began to laugh.

Physical Effects of Standing and Walking.

Second—What are the effects of standing and walking upon the body? In the first place, after children have learned to walk and have gained confidence, they become passionately fond of it and, Gross has observed the same fact with reference to their play, there is a tendency to walk until exhausted, which produces a general physical change. This fact seems sufficient to break down the surplus energy and pleasure and pain theories of walking as well as playing. The metabolic processes are increased, the circulation of the blood becomes more rapid, the respiration increases, the appetite often increases to a marked degree. Children who have been pale and sickly before, often become ruddy and strong, possessed with new life and over-flowing with energy. At the time the first step is taken, the face becomes flushed, the breath short and panting and the whole body often trembles with excitement and eagerness. The fatigue which sets in, is at times so great that sleep is impossible, and when induced the body twitches and tosses from side to side.

Effects on Different Parts of the Organism. The change produced on the muscular system by walking is most marked. The great muscles of the calf of the leg, the tricept extensor suræ, are much increased in size, the psoas ilíacus and pectinéus of the upper part of the leg become hard and resisting. At first, there may be a marked decrease in the size and fullness of the leg which is due to the rapid loss of fat before the muscles have had time to develop. The great glutaei muscles of the buttock and the erector muscles of the spine grow in size and complexity, the latter fill up the vertebral grooves and send up tendons along the back like stays supporting the masts of a ship. These are the characteristic muscles of man and they are comparatively undeveloped previous to this time.

But muscles are easily fatigued and in order to compensate this, the joints and ligaments are fully developed. The body is so held that the center of gravity falls directly upon the ankle-joint, this produces the greatest stability and reduces the muscular force to a minimum. At the knee the center of gravity falls a little in front of the axis of the limb, the back and sides of the joints are provided with check ligaments to hold the joint locked in a position of hyper-extension, so that no muscular force is required to maintain it. In the first efforts of the child to stand, the knee is bent forward hanging the entire weight of the body in the contraction of the muscles, but as he extends the legs the joints become locked and static.

M., 5 yrs. Theodore never liked to be dirty nor romp out of doors, he eats very little, is pale, good tempered and always quiet.

F., 2 yrs. Edith is always running about and would much rather climb and run than play with her dolls. Her circulation is good, her

cheeks have color, she is always full of life. I think it is the romping out-door life that makes her physical condition so different from her brother's.

F. When she had walked until tired, she would continually fall down.

F., 12 mos. Marie seemed to grow more after she commenced to walk.

M. When Walton first stood he got very nervous. In a short time he would fall down. There was a tendency to use his hands more. He became stronger, healthier and more active as he walked more. He required more food. He often ran away.

M. After he found that he could walk he was doing it all the time, when asleep he would moan and twitch from sheer exhaustion.

F., 2 yrs. Alma was very sick until she was two years old. Then she began to walk and she gained in health. She was entirely well at four years of age.

At this time there is a marked increase in the size and fullness of the legs.

F., 2 yrs. The child had walked for some time, one morning she could not use her legs at all. She had n't been sick nor had she fallen. The doctor could not account for it. By constant rubbing for two days she was able to walk again.

M. As soon as the child began to walk, his appetite was better but he became thinner.

The child got so fatigued that it could not rest at night. Children as a rule walk too much.

M., 18 mos. There was a marked increase in the child's appetite. The general disposition is better, it cried less after it had learned to walk.

F., 16 mos. Her breath was short and quick. There was a marked increase in the size of her legs.

F., 2 yrs. She slept better and had a better appetite and was immensely more mischievous.

Rhythmic Movements of the Arms.

Arms. An increased activity is seen in the movements of the arms and hands. There is a rhythmic movement in the arms which alternates with the movements of the legs. The child also has a passion for carrying objects. One child could walk more securely when it carried in its hand the folds of its dress. Several observers noticed that the child acquired greater skill in the use of its hands in examining various objects, while walking. This is due to the general development of the muscular system and it also absorbs the attention of the child, giving the lower center fair play.

M., 10 mos. At this time the arms are used also as much as the legs.

M., 14 mos. After walking he made greater use of his hands. Became more active in examining objects round about him.

Children like to use their hands carrying things while walking.

F., 20 mos. The child learns to use its hands more successfully when it learns to walk.

Mental Effects.

F., 16 mos. When she succeeded in standing she laughed and crowed.

F., 2 yrs. After Magdeline learned to walk she seemed to be a great deal happier.

F., 10 mos. Helen was happy whenever she made a step, she would look around and laugh, then would jump up and down by bending her knees, without raising her feet from the floor.

M., 11 mos. Since Fred learned to walk there has been a marked change in his temper. He was very cross and cried easily, now he rarely cries.

M., 1 yr. The child seemed happier and sweeter tempered after he learned to walk.

Third—How does standing and walking affect the child mentally? With the ability to creep there comes a desire in the child to push out and enlarge its sphere of activity. This desire is increased with the ability to walk. There is a keen desire to explore every unknown region and to examine every unfamiliar object. The emotional life receives a new stimulus. The child becomes elated over its own accomplishments. How the little one laughs for joy when it can rise up near a chair and is conscious that some one is seeing it. One observer writes that the "little girl slapped the seat of the chair near which she was standing with her hands, then turned to her mother with an expression of great pleasure upon her face."

The child grows happier in spirit, it can busy itself in its walks by examining new objects, thus receiving new external stimuli. One mother says—"After Fred learned to walk there has been a marked change in his temper. He was very cross and irritable, he cried very easily, now he rarely cries."

Should Parents Assist Children in Learning to Walk?

The question was asked whether parents should assist children in learning to walk. There were seventy-five answers given, all of which indicate very clearly the one fact. That is, that the assistance of parents should be to prevent falling, which incurs physical injury, discouragement or fear. But they should not lend this assistance until the child first makes the advances, nor should they encourage the child at any stage except as it may lack courage, or if there is danger of post maturity. This is fundamentally in accord with the line of development. At the functional stage the desire appears in the normal child; but it may be inhibited by the effect of another stimulus as was seen in the child who stopped climbing after he had learned to creep. The physiological effect of walking is important here. After an organism has functioned, the growth is much more rapid, we see this in the case of a boy who was very small and pale and inactive until he learned to creep and walk, then the whole organism apparently received new life, the metabolic processes increased and the child grew strong.

Post maturity may thus be avoided by the suggestions and assistance of parents without endangering the normal development of the lower limbs.

These returns leave no place for the walking chair nor any other mechanical devices of body braces, etc., for the child's assistance, and they agree with Dr. Ploss that the child will learn by its own efforts. But there is a deep pedagogical principle underlying the co-ordinations of these early attempts. If the average normal individual can be assisted at the proper times so as to avoid the dangers of mental discouragement, the realization of his growing power will soon be evident. Few children have sufficient combativeness to prevent, at this time, a breaking down of the co-ordinations which have formed in the nerve centers during the earlier successful attempts by injurious falls. The problem of the psychology of success is awaiting a scientific investigation, but it is a matter of common experience that every successful step is so much gain in favor of the next succeeding. Let the individual feel that he *can* do, and having once experienced the doing he is essentially stronger physically as well as mentally for the next similar action. Observations made upon children show that they are indeed very responsive to such conditions.

REVERSION.

According to the famous riddle of the sphinx, man shall again surrender his upright posture and turn his face toward the earth from whence he came.

We have thus far traced his rise, let us now observe some of the causes of his reversion. For a considerable time after children have learned to walk and run, they frequently revert to their early stage of creeping, due to some physical or psychic disturbance. The effect upon the organism, of whatever cause, may be temporary or permanent.

The temporary reversions may be due to—fits of anger and crying or laughter mingled with fatigue; to fear resulting from a fall; to various children's diseases which divest the organism of strength during the early walking stage, so that the child, upon recovery, must learn to walk "over again." When the child is asleep the body curls up, approaching its earlier stages, or when in a hurry the early creeping movements will be resumed. While insanity, deformities, nervous and muscular diseases more frequently cause permanent reversions and old age completes the cycle.

Let us now consider more in detail these tendencies so common, yet so unfamiliar, in the development of the human being.

A fall during the early walking stage, which does not produce physical injury or cause fear, is of little consequence to the

average child. It simply has the effect of a slight annoyance which only invites greater persistence. But if the fall produces a physical injury or is of a serious nature to frighten the child, it becomes exceeding discouraged, which will frequently destroy all confidence even to make an attempt for days, weeks, and in extreme cases even years. One observer speaks of a child who, while attempting to walk, fell upon a lifter which was lying upon the floor and cut his head. He became so discouraged that he did not attempt to walk again for almost two months. Another mentions a little girl two years old who had walked for about two weeks when she received a severe fall. It made her so timid that she would not attempt to stand up after that for a month. When urged to walk by her mother she would say—"I's 'fraid."

Miss Shinn has observed an interesting point in her niece. While the child was on a railroad trip, with its parents, of five days' duration, during the early walking stage, and was carried much in the arms, she became less disposed to stand and creep. For when she returned, she crept shorter distances, she only reached toward some desired place or object; and when the distance was about 12 or 15 feet she would creep it unobserved, but if noticed, she wished to be carried.

Effect of Falling.

F., 10 mos. She seemed to enjoy falling as she never hurt herself by it. She always tried again after a fall.

F., 2 yrs. When Sarah was two years old she fell down stairs while trying to walk down. From that time until she was four years old, she would never try again, but must be carried down.

F., 1 yr. Helen, while learning to walk had a severe fall, and was hurt quite badly. For about a week she would not even try to stand and seemed very timid when she finally did try.

M., 6 yrs. This child could walk very well when two years old. He received a bad fall which injured his spine, after that, it was a year before he walked again. He is now six years old, and yet, when he walks, he drags his feet.

M. When attempting to walk he fell upon a lifter which was lying upon the floor and cut his head. He was so discouraged that he did not attempt to walk for almost two months.

F., 2 yrs. Ruth had walked for about two weeks when she received a severe fall, which made her so timid that she would not attempt to stand up after that for a month. When asked to walk she said—"I 's afraid."

F., 16 mos. When she fell, she was not at all dismayed or discouraged.

F., 10 mos. When Marie fell she would not try to walk again for some time, it frightened her.

M. The falls which this child had were not of a serious nature and after each he would get up and try again.

Effect of Fright.

M. A little boy who had not been seen to stand alone before was noticed one day to stand in the middle of the floor. Several persons

who saw him cried aloud in surprise. The child sat down and could not be made to stand again for some months, the cries having frightened him.

F., 10 mos. One day Helen laughed and jumped so much that she got out of breath and fell over, she showed by the expression on her face that she thought that I had thrown her over and was afraid of me for some time, yet she tried again.

M., 21 mos. When warm weather came, Russell ran out of doors and climbed up the grape arbor. When he got up a certain height where he could go no farther, he began to be frightened. He was aided in getting down by the observer and after that avoided the arbor.

F. Elizabeth gained better control of her hands when she walked, she would go to her mother's work basket and carry away the thimble and thread. One day she pricked her finger with a needle and after that she was afraid to go near the basket.

Hurry.

F., 20 mos. When twenty months old she would run away, but whenever she wanted to get anywhere in a hurry she would always get down on the floor and creep faster than she could walk.

This child had the habit of creeping on its elbows and knees, but when it wanted to go faster it would roll over and over.

F., 12 mos. When Retta had learned to stand and take several steps alongside a chair and saw an object that she wanted to get quickly she would roll over and over toward it, this being her earlier manner of locomotion. This was also the method employed by her mother in childhood.

M., 9 mos. His natural manner of movement was on his stomach pushing himself forward with his hands and knees. When in a hurry, he spread his hands and feet so that he seemed to crawl like a crab.

M., 8½ mos. G. creeps in several ways. If he sees something which he wants, he first gets on his hands and knees and starts forward. This way does not seem fast enough, so he turns and pushes himself backward (still on his hands and knees). Finally, as if all impatient, he lies down flat upon his back and rolls over and over until he reaches the object. He always tries these three methods if he is in a hurry, but ordinarily he simply creeps, usually backwards.

Laughing. The physical act of laughing, as described in [1]Drs. Hall and Allen's study on the "Psychology of Tickling, Laughing, and the Comic," appears to be one of the very common causes of reversion. At first laughing causes a "feeling of bubbling over," "a ticklish sensation in the stomach," a feeling to "laugh or burst," as a "store of energy which must be expended to relieve a strain," and various other feelings akin to these. Then the lips curl, the body becomes unsteady and sways back and forth, the head is at first thrown back and the mouth opened wide, then the muscles of the neck jerk, the head falls forward, the shoulders shake, and the body doubles up convulsively. Sometimes the subject may fall upon the floor and end with sobs and crying or is seated doubled up with his elbows akimbo or planted upon the knees holding his sides; the body rocking violently back and forth. The limbs jerk, the

[1] *Am. Jour. of Psy.*, Vol VIII, No. 2.

feet stamp and the fists pound. The breast heaves and the diaphragm moves at times almost convulsively. Little children jump up and down, lie on the floor and roll all over the room. The fit of laughter is followed by a state of fatigue and soberness with intermittent sighs, heavy breathing, weakness localized in various parts of the body, stitch in the side and soreness, sweating, chills, uncontrollable movements, etc. A study of the physiological effects of violent laughter, as has been shown by Dr. Hall in the majority of adults, are first seen to begin with the highest level in consciousness, of the Hughlings-Jackson theory, "with the finer muscles, and passes downward to lower levels and more fundamental and early developed musculature, although in some children this order is exactly reversed. Expectation, perhaps all that is available, is strongly generated in the higher regions of consciousness; the resulting movements pass down the genetic and perhaps meristic levels till circulation, glandular, and even intestinal and excretory activities are affected and the sphinters relaxed. Let us now consider a little further the physiological effects of laughing and crying as well, since their effects are the same physiologically whatever other differences there may be. [1] The weight of the viscera in quadrupeds is hung from the horizontal spine by means of a strong elastic suspensory bandage of fascia, the tunica abdominalis. In man, who has assumed the erect position, the weight of the visceral organs is thrown upon the long girdle, hence the pelvis has adapted itself by becoming more dish-like. The tunica abdominalis, in man, near the thorax has entirely disappeared; in the groin, where it is of use, it still remains to strengthen the weak parts. It is quite common in children that a fit of crying or violent laughter may cause such intense downward pressure that the muscular ligament of the abdomen is insufficient to withstand it and the ligament breaks, which is testified by the prevalence of hernia. A mild form of the strain upon these comparatively unsupported parts is evident in the feeling of weakness, the stitch in the side and soreness in the groins. As the body is thrown forward in violent laughter, and doubled up, these parts are considerably strengthened by a counter pressure of the legs and ribs as they approach each other.

Sleep. All the various positions assumed during sleep are reversionary, except the one in which the subject lies upon his back. [2] Dr. Osborne has investigated the most favorable position at the various ages of life. He found that children under fourteen years sleep equally on the right side, the left side and on the

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[1] *D. F. Baker:* Am. Assoc. for Adv. Viscera, 1890.
[2] *Osborne:* Dublin Quarterly Journal of Med. Science, 1859, Vol. XXVIII.

back; but that young girls and youths from fourteen to twenty years of age sleep most often on the right side. Fifty-nine cases slept on right side, twenty-nine on the back and twenty-three on the left side. In the side positions the arms and legs are curled up near the body and the spinal column more or less curved forward. Soldiers have also been observed to sleep more often on the right side than on the left. [1] Marie de Manacéine has for the last five or six years made observations concerning the favorable effects of changing the positions of the body as often as possible during sleep and believes it to be hygienic for a person to lie upon the stomach at least half an hour every morning before rising. She has observed that this position, if taken every day, exercises a salutary influence on angina pectoris, and other diseases of the chest and throat. Marie de Manacéine has also observed that little children have a marked tendency to sleep in this position, flat on the belly, but they are broken of it, she says, by parents and nurses, evidently from the fear that they may acquire bad habits.

It is evident that man is forced to pay a toll to the god of nature for this privilege, which he has over other creatures, that of turning his face heavenward, by having visited upon him various disorders and diseases from which animals are entirely free.

The influence of the upright position is seen on the circulation. In the horizontal position, the great vein trunks favors an easy flow of blood to the heart without too great acceleration. Dr. Baker[2] has observed two mechanical defects which man, in the vertical position suffers; first, the difficulty of raising the blood through the ascending vena cava, causing congestion of the liver, cardiac dropsy, and other similar disorders, and second, the too rapid delivery through the descending cava, causing syncope or fainting if for any cause the action of the heart is lessened.

Clevenger discovered that the valves of the veins are arranged to favor the horizontal position. In the large vertical trunks, where they would be most effective to resist the action of gravity, Clevenger found in the most important trunks the valves wanting, which causes disorder due to hydrostatic pressure, varicose veins, varicoceli, hemorrhoids, etc. He found them present in some of the horizontal trunks, where, so far as can be determined, they serve no purpose. Place man in bed and the valves are arranged with reference to the action of gravity in the horizontal position.

When the sick man retires or the weary man lies down it is

[1] Marie de Manacéine: Sleep, its Psychology, Pathology, Hygiene and Psychology.

[2] Dr. F. Baker: Am. Assoc. for Adv. of Sc., 1890.

not merely a conventional matter but one of deep physiological significance. Since it adjusts the position of the body to the most favorable condition for the action of the vital organs, as well as a general relaxation of the organs.

There is, also, a word to be said in favor of the position upon the stomach and face from a physiological point of view. It may appear an uncomfortable position, yet children prefer it to any other.

The back position will cause the viscera to rest their weight upon the descending circulatory trunks, at times a stomach full of food is added to the weight and the trunk circulation may be below normal while there may be an abnormal flow of blood to the brain through the ascending aorta. The position in sleep, then, is not a matter of entire indifference, but may have considerable influence upon the general health.

Diseases. The effects of the common children's diseases are of a little more serious nature than those of falling. The organism is depleted of its strength while valuable time is lost at a critical stage in practice. The returns show conclusively that a child may have sufficient strength to carry the body but he has simply forgotten the movements. A pitiful case was reported by a mother whose child had been ill for two weeks with the measles immediately after he had learned to walk. The disease had not been serious, but it had kept him in bed. After recovering, when he tried to walk again, he did not know how to do it. He manifested great surprise and chagrin at his failure, for he remembered that he had walked before. After his mother showed him how to place his feet, he eagerly and successfully followed her instruction. This lighter form of disease depletes the physical strength but temporarily, and upon recovery it is soon restored without entirely destroying the mental image or the nervous co-ordinations. There is, however, another form of disease which strikes at the fundamental root of motor-life, hence it invariably proves fatal to the muscles involved. These are the diseases characterized by the progressive weakness and atrophy of certain groups of muscles, or cerebral lesion which ·ldom causes paralysis of the lower without similarly affecting : upper extremities.

The term "progressive muscular atrophy" was formerly ap- ed to a single type of disease which was considered a desig- ion for an entire group of diseases. Later study, however, ablished two distinct diseases instead of one—the first was "progressive muscular atrophy," as described by Aran and henne; the second pseudo-hypertrophic muscular paralysis. ous different forms of these have been described by recent ents. The various types of progressive muscular disease

have been established in accordance with their topographical distribution of atrophy and hypertrophy.

The so-called "progressive muscular atrophy" is a spinal-cord affection which, as a rule, begins late in life. It begins, in general, with an atrophy and a corresponding weakness in the small muscles of the hand, whence it extends from muscle to muscle to the deep muscles of the thenar, to the flexors and extensors of the forearm. Then to the flexors of the upper arm, and finally to the muscles of the trunk, shoulders and back. Duchenne recognized the fact that atrophy may, in exceptional cases, begin in the trunk, shoulders and legs. Sachs[1] observed several cases in which atrophy in the lower extremities began almost simultaneously with that in the upper extremities. As this disease progresses the wasting of the muscles becomes more and more extreme. The patient loses power of locomotion and becomes bed-ridden from which death releases him after many years of annoyance.

Hoffmann cites the case of a girl four years of age: At birth the child was entirely normal, she was able to stand at nine months of age. There was an early abnormal development of adipose tissue. Gradually the child became so weak that she could not stand, could not sit upright in bed, could not turn around without assistance. For a long time she was unable to move her feet and arms. She lost her superfluous amount of fat as the motor disturbances increased gradually and became emaciated especially in the extremities and the trunk.

The face remained full, mentality good, speech normal, mastication unimpaired, the child could turn the head but could not raise it from the pillow. The paralysis was in proportion to the atrophy of the muscles. The nerve-trunks were neither thickened nor sensitive on pressure. The paresis and atrophy of both upper extremities were entirely symmetrical, and the sensation was normal.

The muscles of the back and abdomen were paretic, the long erectors of the back diminished in volume and power. The gluteal and muscles of the thigh were almost completely paralyzed and very atrophic. The muscles of the leg were atrophic and paretic. The movements of the toes were almost normal. The paralysis was symmetrical and flaccid leaving no sensory disturbance.

Muscular Pseudo-Hypertrophy is characterized by its occurrence in early youth. It has been considered as the most pronounced form of primary myopathics, and not of spinal origin. But as new types of muscular diseases were described the cases reported inclined rather to the spinal than to the pseudo-hyper-

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[1] Sachs: Nervous Diseases of Children, Chap. XXIII.

Dr. Ireland[1] investigated the development of 111 cases of idiots who learned to walk. The average time at which they learned was at the age of 2½ years. Five of these are stated to have begun to walk at one year. This lateness in learning to walk, according to Dr. Ireland's report, may be due, in some cases, to weakness, in others to nervous disease, but there are cases where the child appeared strong and healthy, and the deficiency was in the power of mental guidance. The gait was awkward and was acquired along the line of least expenditure of effort, and it was never changed or improved. If the children were required to walk upon a plank, they were successful according to the degree of intelligent. The most intelligent succeeded best. They balanced the body poorly, the hands were flapped or vibrated about instead of being employed to seize and hold with intelligence.

A comparative study of idiots and imbeciles and normal children produces a valuable suggestion which shows in a measure conclusively the part played by intelligence in learning to walk. The average age at which normal children begin to walk is 12 months. (Dr. J. Crozier Griffith—Care of the Baby.) The imbeciles, according to Dr. Ireland, begin at about 2½ years. There is a difference of 1½ years that the normal child has the advantage. The physically abnormal idiots are ruled out, so that under normal conditions the organisms would function at about the same time in the two cases. But we see a difference of 1½ years. This difference may be due to two causes. First—the psychic activity of the idiot is more sluggish than that of the normal child. He may receive the same stimulations but these do not establish the same associations in consciousness, hence he lacks the prevision of the normal child. This produces the second or physiological cause. The functioning of the organs is delayed because of a failure to take advantage of wholesome exercising and experience. The former to stimulate the organism, the latter to form the basis of new and higher activity. When both the imbecile and the normal child arrive at the age of twelve months, the latter has been responsive and has been stimulated to activity, his bodily organs are stronger; he has profited, the latter has not. One child devises methods to give expression to the natural desire within him, and often changes these; the other accepts the more simple means which require the least mental effort and they are adhered to without change.

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[1]Mental Affection of Children.

CONCLUSIONS.

[1] "Nature has succeeded in making a man; she can go no farther. Organic evolution has done its work." In the foregoing chapters we have seen how the human organism has assumed the upright position, expressing the fullest range of possibility and the limit of organic evolution. In concluding, let us further consider the effects of this attitude upon the mental life. [2] Masso has said that the mobility of an animal is an index to the intelligence of it. "Among all birds the parrot is the most intelligent, because it makes more use than do all the other birds of its legs, beak and tongue. The elephant is more intelligent than all other wild animals, because he makes use not only of his legs, but also of his snout as organs of movement."

If the state of intelligence depends upon mobility in animals in general, whose limbs are used entirely for locomotion, what an enormous advantage is given to man over other creatures. His bodily size and weight is midway between the small and feeble creatures and the large and clumsy, thus combining grace with strength; and his body is balanced upon one pair of limbs, setting the others free. The movement of the arms is as varied as a free-moving radius of a sphere; add to this the infinite number of movements of the digits and there is a complexity of enormous significance which sends its impulses to the central nervous system. Indeed some of the modern writers consider that human intelligence, as such, has arisen in direct consequence of man's assuming the upright position, [3] so close is the relation existing between the mental life and muscular movements. Many persons consciously experience this in not being able to think if they suppress the muscular movement.

If we accept with Höffding the conclusion that mental and physical activity are not different things, but opposite sides of the same thing, we can accept the axiom that the mind can only be educated through the senses, and the more senses and the better they are developed the greater will be the possibility of mental power.

…ly are the arms and hands by the erect position to …w and varied stimuli but the eye is raised enlarging …f vision in the farthest horizon, enabling it to act like …or the other senses against friend and foe. The eye … the skull so that there may be the greatest possible … of attention. Perhaps it is that advantage which …gain in their wider range that gives man a passion

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…nd—Ascent of Man, p. 99.
… Volume Clark Univ. Address.
…: Bewegungs vorstellungen.

for climbing high hills and mountains, that he may look about over the wide expanse. What a feeling of exultation does he experience as he views the plains, cities and living creatures lying at his feet.

The proud and haughty spirit is not common in short and stooping persons, but it manifests itself iu the strut of the pompous person which plainly over emphasizes the upright position.

The attitude of prayer is not without its significance.

The meek and humble veil their faces and lie prostrate; the Greek, who stood erect with up lifted countenance offering soul and body to Apollo, the god of health and beauty, furnish us not only a most perfect type of physical strength and beauty but his intellectual power has been the admiration of the world.

Physical and mental life, in the race, in the individual, come into being; pass through simple to complex stages by a slow process of development; reach their zenith of power and return, making the cycle complete. But a slight disturbance in either body or mind, a disease, a passion has a tendency to undo shortly what has been a long and difficult process of growth.

It is a pleasure to make acknowledgments to President G. Stanley Hall for suggesting the subject of this paper and for delivering to me a syllabus and a number of returns, also for his valuable suggestions and criticisms from time to time; to the other members of the faculty of Clark University and to the physicians of the city hospitals of Worcester for their assistance from many sources; to Mrs. A. W. Trettien for her assistance in summarizing the results obtained, and to the many others who so carefully recorded and sent the facts of their observations, I am grateful.

substituted with reagents G. and B. (experiments of '96-'97); they were:—

6° Listening to interesting reading. (H'r'g.)

7° Discriminating between pairs of clangs differing by 8, 4 or o vibrations. (D'c'n.)

As a comparison of two tones requires a period of at least 3 seconds, and again as it takes an appreciable time for interest to be aroused in listening to reading, these last 2 forms of distraction could not be used for the shorter intervals; they were accordingly applied only to intervals of 10, 20, 30, 40 and 60 seconds. On the other hand it is to be said that distraction for the one second interval can mean only that the 'set' of the reagent's mind is different from that for an unfilled interval.

Inasmuch as the several forms of distraction are applied to six different norms for the reagents G. and B., and to three different norms for reagents L., W., A., and S., it will first be necessary to consider the relation of pitch to the number of

TABLE V (a).

Percentages of right cases [r] of reagents L., W., A., S., for the norms 540, 560, 580, with differences [Δ] of 8, 4, o vibrations, with and without the Distractions Ad., Rd., Lt., M^1, M^2. Each percentage given is usually based on 72 judgments for norms 560 and 580, and on 36 judgments for norm 540. Nine (9) time intervals from 1 to 60 sec.*

Reagent.	Norm.	No. D'n.		D'n.		No. D'n.		D'n.		No. D'n.		D'n.	
		Δ	r		r	Δ	r		r	Δ	r		r
L.	560	8	94	Ad	96	4	81	Ad	83	o	42	Ad	25
	540	8	98	Rd	94	4	91	Rd	86	o	64	Rd	41
	580	8	91	Lt	87	4	85	Lt	91	o	41	Lt	8
	580	8	96	M^1	93	4	82	M^1	84	o	50	M^1	28
	560	8	92	M^2	98	4	78	M^2	88	o	53	M^2	11
W.	560	8	86	Ad	79	4	60	Ad	64	o	64	Ad	63
	540	8	96	Rd	94	4	84	Rd	72	o	72	Rd	61
	580	8	90	Lt	83	4	78	Lt	75	o	81	Lt	49
	580	8	91	M^1	91	4	74	M^1	66	o	69	M^1	37
	560	8	93	M^2	78	4	66	M^2	68	o	56	M^2	56
A.	560	8	89	Ad	83	4	71	Ad	71	o	72	Ad	60
	540	8	88	Rd	90	4	88	Rd	75	o	73	Rd	63
	580	8	86	Lt	88	4	72	Lt	71	o	78	Lt	65
	580	8	92	M^1	94	4	70	M^1	73	o	83	M^1	56
	560	8	96	M^2	95	4	81	M^2	72	o	70	M^2	42
S.	560	8	59	Ad	42	4	54	Ad	53	o	19	Ad	13
	540	8	64	Rd	73	4	60	Rd	61	o	25	Rd	25
	580	8	60	Lt	61	4	45	Lt	72	o	44	Lt	13
	580	8	57	M^1	66	4	55	M^1	53	o	33	M^1	22
	560	8	49	M^2	47	4	50	M^2	44	o	28	M^2	14

*In the case of A. the percentages are based on 60 to 72 judgments.

TABLE V (b)

Percentage of right cases (r) of reagents G. and B. for norms 540, 560, 576, 640, 660, 768, with differences (△) of 8, 4, 0 vibrations with and without Distractions Ad., Rd., Lt., H'r'g, D'c'n. Nine time intervals, 1 to 60 seconds, unless otherwise specified.

Reagent.	Norm.	△	No. D'n.		D'n.		△	No. D'n.		D'n.		△	No. D'n.		D'n.		Kind of D'n.
			No. Cases.	% r	No. Cases.	% r		No. Cases.	% r	No. Cases.	% r		No. Cases.	% r	No. Cases.	% r	
G.	540	8	72	92	72	93	4	67	75	68	88	0	36	67	36	67	Ad.
	560	8	71	93	72	90	4	72	75	72	81	0	36	48	36	31	Rd.
	576	8	72	90	72	76	4	72	76	72	63	0	36	50	36	19	Lt.
	640	8	72	81	70	75	4	71	68	70	55	0	36	47	35	43	H'rg. *
	640	8	64	91	64	73	4	64	66	64	64	0	32	22	32	22	D'c'n.*
	660	8					4	80	79	80	59	0	20	40	20	35	D'c'n.*
	768	8					4	80	64	80	67	0	20	35	20	25	D'c'n.*
B.	540	8	68	93	66	87	4	67	85	68	79	0	36	78	35	66	Ad.
	560	8	72	83	68	84	4	72	93	72	84	0	36	81	36	66	Rd.
	576	8	72	83	70	83	4	72	79	72	67	0	36	75	32	56	Lt.
	640	8	72	76	70	80	4	70	59	67	58	0	35	43	29	34	H'r'g.*
	640	8	64	92	62	77	4	64	73	64	62	0	32	41	32	53	D'c'n.*
	660	8					4	80	77	80	77	0	19	42	20	40	D'c'n.*
	768	8					4	80	42	80	44	0	19	32	20	35	D'c'n.*

* Intervals of 10, 20, 30 40, 60 sec.

right and wrong judgments before proceeding with the discussion of the effects of distraction. Table V gives a summary for all time intervals of the percentage of right judgments for all norms, and for all forms of distraction with the three differences of vibration (8, 4, 0,) between norm and variable. Luft, as is well known, found that the absolute discriminative sensibility was about constant for the region which includes our norms.[1] Wolfe's results on the other hand indicate rather a decrease in the number of right judgments with the increase in height of tone,[2] whilst Meyer reports a fairly constant value for the region 200 to 600 vibrations and a lower value for 100 and 1,200 vibrations[3] with Stumpf as reagent.

Our results with the first set of reagents (Table V a) show more correct judgments for N = 540 than for N = 560 or 580, but in some cases less correct judgments for 560 than for 580. These norms, however, differ so little that for the first set of results the question of the relation of pitch to discriminative sensibility need not be taken into account.

For reagents G. and B., taking the extremes of norms used under similar conditions, the averages for differences of 8 and 4 vibrations (without D) are:—

Per cent. right cases for G. and B.

Norm.	$\Delta = \pm 8$	$\Delta = \pm 4$	Norm.	$\Delta = \pm 4$
540	92.5	80.0	640	66.5
576	86.5	77.5	768	53.0

The experiments with norms 640 and 768 are based on results with time intervals 10 to 60 seconds, and therefore are not strictly to be compared with the results from norms 540 and 576. The indications from these figures are in favor of a decrease in the absolute sensitiveness to difference with increase in pitch; but the mean variation of these averages, if they may bear the name, is too great to permit much reliance to be placed on the indications. We shall, therefore, proceed to the discussion of the distraction experiments without regard to any general law of variation of the liminal difference with pitch.

Of the seven (7) forms of distraction mentioned above, the 'intonation' of interesting literature, and the listening to reading were the most distracting in the sense of being the most

[1] Luft: Ueb. d. Unterschiedsempfindlichheit f. Tonhöhen. Phil. Stud., V, S. 529.

[2] Wolfe: Unt'g ü. d. Tongedächtniss. Phil. Stud., III, S. 561.

[3] Meyer: Ueb. d. Unt'dsemp'k't f. Tonhöhen. *Z. f. Psy.*, XVI, S. 357.

TABLE VI.

Number of instances of increase, equality and decrease in percentages of right cases for all forms of distraction as compared with the percentages for undistracted intervals.

	No. of instances of increase in % of right cases with distraction.			No. of instances of equality in % of right cases with distraction.			No. of instances of decrease in % of right cases with distraction.		
Δ =	±8	±4	0	±8	±4	0	±8	±4	0
Reagent L	2	4	0	0	0	0	3	1	5
" W	0	2	0	1	0	1	4	3	4
" A	3	1	0	0	1	0	2	3	5
" S	3	3	0	0	0	1	2	2	4
" G	1	2	0	0	0	1	4	3	4
" B	2	0	1	1	0	0	2	5	4
Total	11	12	1	2	1	3	17	17	26

could conclude that it increased the accuracy about ⅔ as often as it decreased it, and in a few instances had no effect.

Very different are the results or the accompaniments of distraction for $\Delta = 0$: only once do we find any instance where the distraction was accompanied by an increase in accuracy of judgment, while in 26 instances the accuracy was decreased. Here, as in the effects of the flight of time without distraction, the objectively like cases seem to differ indeed from the unlike this stimuli in their relation to the processes of judgment, and makes still more questionable the propriety of mixing the results of like and unlike stimuli together into general averages, in these so-called memory experiments.

The next questions that naturally arise are:

1° Is the excess of about ⅓ wrong judgments in the experiments with distraction for differences of 8 or 4 vibrations to be attributed to any particular forms of distraction?

2° Is there any correspondence between the reagents' estimate of the depth and absorbing power of a given distraction and an increase in wrong judgments? Tabulating the instances where D was accompanied by an increase or a decrease of right judgments, or where no change took place, we find for the several values of Δ and for the several kinds of D the following table.

An effect of distraction apparent in the following table is more noticeable in this: it is that distraction affected differences of 8 and 4 vibrations about equally; for 4 reagents with 5 forms of distraction a difference of 8 vibrations resulted in 8 instances of increase and 11 of decrease in the percentages of right judgments, and a difference of 4 in 9 instances of increase and 10 of decrease. For six reagents with the first 3 forms of distraction, the corresponding figures for $\Delta = 8$ and $\Delta = 4$

TABLE VII.

Increase (in.) decrease (de.) and equality (eq.) in percentage of right judgments in distraction comparisons.

	REAGENTS B. & G.									REAGENTS L.W.A.S.									TOTAL REAGENTS B. G. L. W. A. S.								
	±8			±4			0			±8			±4			0			±8			±4			0		
	IN.	DE.	EQ.	IN.	DE.	EQ.	IN.	DE.	EQ.	IN.	DE.	EQ.	IN.	DE.	EQ.	IN.	DE.	EQ.	IN.	DE.	EQ.	IN.	DE.	EQ.	IN.	DE.	EQ.
Dist'n Ad.	1	1	0	1	1	0	0	2	0	1	3	0	2	1	1	0	4	0	2	4	0	3	2	1	0	6	0
" Rd.	1	1	0	1	1	0	0	2	0	2	2	0	1	3	0	0	3	1	3	3	0	2	4	0	0	5	1
" Lt.	0	1	1	0	2	0	0	2	0	2	2	0	2	2	0	0	4	0	2	3	1	2	4	0	0	6	0
" M 1.										2	1	1	2	2	0	0	4	0									
" M 2.										1	3	0	2	2	0	0	3	1									
" Hrg.	1	1	0	0	2	0	0	2	0																		
" Dcn 1.	0	2	0	0	2	0	1	0	1																		
" Dcn 2.				0	1	1	0	2	0																		
" Dcn 3.				2	0	1	1	1	0																		

alike, are an increase of 7 and a decrease of ten (10). These figures are not easily intelligible on the basis of a memory-image theory of comparison.

In answer to the first of the above questions, it cannot be said that the distracting powers of any of these forms of occupation was very much in excess of any other. The first series of experiments with the interpolated discrimination of pairs of tones (Dcn 1) gives, indeed, 4 instances of decrease and none of increase, but the last series (with a different norm) gives 3 of increase and 1 of decrease. And here it may be objected that counting the number of instances of increase or decrease is too rough a way to estimate the effects or accompaniments of distraction, and that the amount of effect as expressed in each percentage should be taken into account. But W., to take one of many examples, drops from .93 to .78 for a difference of 8 vibrations with the distraction M [2], but rises for the same distraction from 66 to 68 for a difference of 4 vibrations. The [illegible]riations of the percentages are too great to permit any com[illegible]ison of them in pairs; but by lumping all the results for kinds of distraction and for all reagents together we get [illegible]res which, if they have no worth as absolute values, illus[illegible]e, in all probability, the general trend of the accompani[illegible]nts of distraction. A further objection might be raised to [illegible] effect that a careful determination of the type to which [illegible]h reagent belonged should have preceded the experimenta[illegible]. It is a fault of the investigation that not enough attention [illegible]given to the observations of the reagents on the mental pro[illegible]n play during the intervals. On the other hand, there was [illegible]nger with comparatively new and very conscientious re-

agents, of stimulating introspection to an extent that would have prevented all regularity in judgment. However, the experiments were in part undertaken to determine what sensory or motor vehicle, if any, existed which carried over the memory image of the first sound to the moment of comparison with the second. To this end we used such a 'drag-net' form of distraction as intoning interesting reading to act at once on any form the memory image might take, together with special aim at the "Mitsingen." In contrast with this was the purely special form of discriminating between tones, which was, of course, designed to act on the acoustic or rather auditory form of memory image. Between the two, with no especial sensory or motor disturbances, lay one of the most efficacious forms of distraction—listening to interesting reading (Hrg).

The question as to the agreement between the subjective impression of the depth or absorbing power of a given abstraction and the decrease in the percentage of right judgments is also to be answered negatively. Beginning with the intonation of interesting reading as the most absorbing form of distraction, next in order came reading letters of words read backwards, and last and least the counting of metronome beats M^1 and M^2. As the discrimination of pairs of sounds affected only 2 reagents we shall consider them separately. Tabulating the results for the 4 reagents L., W., A., S., who were acted on by the above 5 forms of distraction, we find for $\Delta = \pm 8$ and ± 4 the following instances of increase (in.) or decrease (de.) in percentages of right cases as compared with intervals without distraction.

	Rd.	M2	Ad	Lt.	M1
in.	3	3	3	4	4
de.	5	5	4	4	3

There is very little indication here of any correspondence between the depth of absorption and decrease in accuracy of judging. The most absorbing form of D—reading with intonation (Lt), is accompanied more often with an increase in percentage of correct judgments than the least absorbing form, of counting metronome beats at the rate of 1.5 a second. No very great amount of significance can, however, be attached either to the relative or absolute values of these figures; it might happen that experiments with more reagents or more experiments with the same reagents would change the order of the series. But there is very little probability that, except by chance, the figures would ever show even an approximate correspondence between the amount of subversion of judgment and the subjective estimate of the depth of distraction.

As was remarked above, the $\Delta = 0$ comparisons show the effects of distraction much more strongly than the differences

8 and 4, and a more decided answer to the question in regard to the correspondence of depth of distraction and subversion of judgment might reasonably be looked for in these cases. The following table gives the increase (+) or decrease (–) of the distraction judgments for $\triangle = 0$ reckoned in per cents of the undistracted intervals.

TABLE VIII.

Decrease in percentages of correct judgments with distractions for each reagent in $\triangle = 0$ comparisons.

Reagents.	Differences in % for the several forms of distraction $\triangle = 0$.				
L.	M^2 –79	Lt –76	M^1 –44	Ad –40	Rd –36
W.	M^1 –47	Lt –40	Rd –15	Ad – 2	M^2 0
A.	M^2 –40	M^1 –33	Lt –17	Ad –15	Rd –14
S.	Lt –70	M^2 –50	M^1 –33	Ad –32	Rd 0
G.	Lt –62	Rd –35	Ad – 0	—	—
B.	Lt –25	Rd –19	Ad –15	—	—

We have here the somewhat unexpected result that the counting of metronome beats (M_1 and M_2) which is the least absorbing form of distraction, together with the intonation of interesting reading (Lt) which is the most absorbing, seem to have the strongest subverting effect on the judgments, whilst adding (Ad) and reading letters backwards (Rd) have the weakest.

From the memory image standpoint, it does not add to the intelligibility of the situation that M_1 had the strongest, and M_2 the weakest subverting effects on the judgments of W. A further consideration of these results will occupy us in the special discussion of the $\triangle = 0$ judgments; here we have simply to remark that in the cases where distraction seemed to have the strongest influence, there is no congruence between the degree of distraction and the subversion of judgment.

The experiments with discrimination of interpolated pairs of clangs as distraction were carried out with two reagents only—S. and B., but at a considerable length. Three (3) main norms 640, 660 and 768 were used, and three minor or distraction norms 620, 528 and 880, for which $\triangle$ also had the values ± 8, ± 4 and 0. To the 10, 20, 30, 40 and 60 second intervals were applied respectively 1, 2, 3, 4 and 6 pairs of distraction judgments; thus with the interval of 60 seconds, after the main norm came 6 pairs of successive clangs, each pair of which was to be compared in respect to pitch and the judgment noted. Then came the D or main variable clang which was to be compared with the first of the series. The general results of this experimentation have already been given in Table V; in Table IX we give the detailed results for each time interval.

TABLE IX.

No. of right, wrong, like, and doubtful judgments for norms 640, 660, 768, without and with distractions due to discriminating between pairs of sounds. For each time interval and for each reagent 40 judgments with and 40 judgments without distraction. Differences of main norm and comparison ± 4 vibrations.

	Reagent G.								Reagent B.							
	No D.				D.				No D.				D.			
	r	w	lll	o	r	w	lll	?	r	w	lll	?	r	w	lll	?
10 sec.	25	7	8	0	18	13	9	0	20	12	8	0	18	9	13	0
20 sec.	23	11	6	0	23	6	11	0	21	12	6	1	23	10	7	0
30 sec.	22	13	5	0	22	12	6	0	27	11	2	0	20	15	5	0
40 sec.	22	9	9	0	20	10	10	0	21	15	4	0	17	10	13	0
60 sec.	21	12	7	0	22	9	9	0	22	13	5	0	18	11	11	0
Totals,	113	52	35	0	105	50	45	0	111	63	25	1	96	55	49	0

Taking the 'r' cases exclusively we find that G. lost with distraction, for intervals of 10 and 40 seconds—held her own for 20 and 30; and gained for 60. B. loses for all r intervals except for 20 seconds. But if we take the decrease in wrong cases as our guide we find that G. loses twice with distraction and gains 3 times, whilst B. loses once and gains 4 times. If we distribute the 'like' judgments equally between the right and the wrong, we get about an equal number of right cases for each reagent with and without distraction. But it is doubtful if we have any right to make any such distribution in experiments of this kind. The assumption on which such a procedure rests is that the constant and variable errors are similar in kind and in distribution for the equal and unequal stimuli, an assumption, which, as has already been shown, is far from being correct for this form of comparison. Beside the disproportionate increase in wrong cases in passing from unequal to equal stimuli, there is to be added a contradictory tendency in the like judgments according as they are applied to equal or unequal stimuli. G., for example, shows a tendency to underestimate the second tone for objectively like cases, and to overestimate it when the norm and variable are unlike. In some of the preceding tables the likes and doubtful judgments have been distributed between the right and wrong cases, for the sake of comparison with similar tables in other investigations, but the writer feels that the warrant for applying the general procedure in the method of right and wrong cases to experiments of this kind has yet to be shown.

The results of the experiments with distraction reflect very fairly the different opinions of different psychologists in regard to the effects of attention during the time interval. Wolfe

inclines to the belief that the accuracy of comparison depends in great measure on the exertion of attention during the interval,[1] though he remarks cases where no trace of the first tone seems to be present for the attention to act on. Lehmann, on the other hand, found that his reagents could discriminate better between gray disks if they did not concentrate their attention on a memory image in the interval.[2] Hamlin finds that the application of attention to the first stimulus during the interval is more likely to distract than to fix the fading memory image.[3] Radoslawowv concludes that a distraction of of attention during the time interval actually increases the "sharpness" of memory for lines, and his explanation of this result is that by repeated reproductions of the norm the memory for it becomes 'blunted;' when, however, the mind is otherwise busied in the interval of comparison the original impression remains fresh, and its reproduction through the associative action of the second stimulus can take place with greater ease and accuarcy.[4] In view of this explanation it is not going too far to say that had Radoslawowv's results shown an increase of accuracy with attention directed to the memory image of the norm, the effect would have referred to the law of repetition. So plastic, to paraphrase Clifford, is psychological explanation when it has physiologic clay for its wheel. But with one form of distraction in particular, Radoslawowv found a marked decrease in accuracy, and this was where a line was exposed shortly before the variable and differing from it by a value not far from the liminal difference. The decrease in accuracy through the interpolation of this line, Radoslawowv refers partly to 'mistaken' comparisons of variable and distracting lines, and partly to a blotting out of the image of the norm. As this form of distraction is analogous to that used by us in our last series of experiments, it may not be out of place to examine Radoslawowv's work somewhat in detail. Using 2 reagents, a norm of 30 millimeters, distraction distances varying from 26 to 34 mm. and a minimal change of 0.5 mm., Radoslawowv found, *e. g.*, that the intervening line disturbed the comparison in the case of reagent Seyfert, so long as it differed from the norm by about 0.8 mm.—the value of the liminal difference for the reagent. It cannot, however, be said that the method of minimal changes was used by R. in a legitimate way, for the 'steps' of the variable were anything but minimal; in the case

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[1] Phil. Stud. III, S. 559.
[2] Phil. Stud. V, S. 127.
[3] Alice J. Hamlin, Attention and Distraction, *Am. Jour. Psy.*, VIII,

[4] Radoslawowv Hadji-Denkow, Unt'sg'n ü. d. Gedächtniss f. raüm-Distanzen des Gesichtsinnes. *Phil. Stud.* XV, S. 366.

of reagent Möbius (p. 400), for example, in 9 sets of experiments out of 18 the minimal change was 0.5 mm., the maximal difference was 0.5 mm., and the mean variation zero, which means that the reagent noticed a change with the very first step in half of the experiments, and that this step was noted as "minimal." In the case of the other reagent, in 34 sets of experiments (10 determinations of the liminal difference to an experiment) the variable was moved 4 steps in 3 sets, 3 steps in 16 sets, and 2 steps in 15 sets. This is hardly more than a travesty on the method of minimal changes. Granting that the method was carefully used, it is hard to see how the introduction of a single line between norm and variable could lead to anything but a series of comparisons somewhat after the method of mean gradation. The writer surmises that Radoslawowv would have had fewer cases of mistaken comparisons had he used pairs of lines for filling the time instead of the mediating single line. How this investigator distinguishes between cases of blotting out of the norm, and false comparison is not clear; the evidence for it, so far as we can see, is deduced from the figures and is not given by introspection.

The main conclusion to be drawn from the distraction experiments is that judgments of tone discriminations can take place, and in the majority of our experiments did take place, without conscious comparison between the present sensation and a memory-image of a past sensation. When, for example, a reagent, after a long time-interval filled with interesting reading, from which he had to be practically aroused by a sharp signal in order to prepare himself for the apprehension of the second tone, nevertheless delivered a judgment with a feeling of considerable security, it is idle to speak of 'memory images' or indeed of comparison in the ordinary meaning of the word. Or when a reagent, after having accurately discriminated six pairs of tones, decided with ease that a tone just given is like or unlike a tone 4 vibrations higher or lower sounded 60 seconds before, and is correct in these decisions 63 times in 100, it is evident that the ordinary theories of tone comparisons need readjustment.

No more is it explicable on the theory of memory comparison that there should not have been a great increase in doubtful judgments in passing from undistracted to distracted discrimination, or indeed in failures to judge at all, or that the several forms of distraction should not have shown a far greater difference in effect than was actually the case. Both introspection and the numerical results in our work point to the form of discrimination which we may term *free judgments* (as opposed to 'bound')—the kind commonly given in ordinary life when we speak of a heavy book or a tall man, etc. Martin and Müller have shown that such a form of judgment existed in their ex-

periments with weights;[1] this form of judgment they call 'absolute,' but we think the term 'free' is probably better for psychological purposes, being already in use for the phenomena of reproduction. This matter of free judgments we shall discuss later in connection with the consideration of the 'like' cases. Meanwhile, it may be worth while to examine more critically than has so far been the case, the value of the memory-image theory as an explanation of discriminative judgment.

2. Memory Image Theory of Discrimination.

What may be called an authoritative statement of the memory-image theory is to be found in A. Lehmann's second research on Recognition.[2] Noting in the comparison of two stimuli, the tendency to overestimate the second, he says: "In the act of comparison the second sensation is always compared with the memory image of the first, and inasmuch as the memory image must be fainter than the present sensation, the latter will be estimated proportionately stronger: *i. e.*, it will be overestimated. As the memory image sinks towards zero with the increase of time elapsing between the two sensations, the more pronounced will be the overestimation of the second sensation."

Lehmann found, however, that the theory was not strictly confirmed by his own experiments on memory for sounds—the sound image, after 6 seconds, for example, "having come back almost to its original strength,"[3] so he falls back on the hypothesis of periodic phases of the memory-image. The additional contradicting fact appearing in his experiments, of the frequent underestimation of the second stimulus, he makes no attempt to explain, and the details which he gives, both in the matter of results and of the conditions of experimentation, are too scanty to enable one to form a fair and intelligent criticism of the work. It does not appear, however, that he became aware of these fluctuating memory images through introspection, or that he made any attempt to show them directly; as in the case of Wolfe, their power seems to have been implicitly inferred —on the basis, probably, of the apparently self-evident proposition, that a judgment involving comparison must come from an act of comparison in which the things compared are present in consciousness.

When we come to extend the notion of a vanishing or fading memory image to other characteristics of sensation and especially to qualities of sensation, it is not clear what is meant by fading or changing, and indeed we find here a reflection of the

[1] Martin and Müller. Anal. d. Unt'demp'k't. S. 43.
[2] A. Lehmann: Krit. und experiment. Studien ü. d. Wiedererkennen. *Phil. Stud.* VII, S. 205.
[3] *Op. cit.*, S. 207.

contradictions in respect to the accuracy of sensory memory noticed in our first article. Thus, it has been deduced that the memory image of a light sensation may fade either towards black or towards white[1] or towards a mean or type.[2] In the matter of memory for colors the question becomes more complicated. Does fading or growing dim here imply a decrease in saturation or a drift towards an adjacent part of the spectrum? Does the memory image for red fade towards pink or cherry, or is it towards orange or purple?

Does the memory image of the first of two successive tones fade towards the high or low end of the tone series, or does it merely fade in intensity and so seem to drift towards low? Turning to Table X we find, for example, for the last reagents

TABLE X.

Distribution of 'like' (111), *'higher'* (h), *'lower'* (l), *and doubtful* (?) *judgments with and without Distraction for reagents George and Bullock.*

Vibrations.	G.	G. No Distraction. 111	h	l	?	G. Distraction. 111	h	l	%	% D	B.	B. No Distraction. 111	h	l	?	B. Distraction. 111	h	l	?	%	% D
	=	24	5	6	—	24	3	9	69	67	=	28	6	2	—	23	7	5	1	78	65
540	h	2	63	9	3	6	56	6	84	82	h	17	56	2	—	11	42	9	—	75	68
	l	15	3	43	1	1	5	76	70	93	l	4	2	53	1	5	5	61	1	89	85
	=	17	7	12	—	11	13	12	47	31	=	29	1	6	—	24	8	4	—	81	67
560	h	4	55	13	—	7	52	13	76	72	h	6	54	12	—	7	55	8	—	75	79
	l	8	4	59	—	2	3	67	83	93	l	19	3	50	—	9	6	55	—	69	79
	=	18	9	9	—	7	7	22	50	19		27	6	3		18	7	7	4	75	56
576	h	5	49	18	—	5	42	25	68	58		3	57	11		9	46	14	3	80	66
	l	4	3	65	—	5	14	53	90	74		5	12	56		13	8	49	2	77	69
	=	17	6	13	—	15	5	14	47	44	=	15	7	13	1	10	11	7	8	43	39
640	h	14	39	19	—	13	36	23	54	50	h	7	55	9	1	2	60	6	1	77	88
	l	3	9	59	—	13	13	52	83	67	l	5	31	34	—	7	10	38	4	49	68
	=	7	11	14	—	5	15	12	22	16	=	13	9	10		17	12	3	—	41	53
640	h	5	45	14	—	9	47	8	70	73	h	1	55	8		5	53	6	—	86	83
	l	9	6	49	—	8	22	34	77	53	l	6	10	47	1	11	24	26	1	74	43
	=	8	7	5	—	7	6	7	40	35	=	8	5	6		8	9	3		42	40
660	h	8	18	4	—	8	13	15	45	36	h	4	29	7		6	31	3		72	77
	l	5	4	31	—	14	7	23	78	52	l	3	8	29		11	7	22		72	55
	=	7	4	9		5	3	12	35	25	=										
768	h	5	18	17		10	17	13	45	43	h										
	l	7	6	27		7	5	28	68	70	l										

[1] Münsterberg: *Psy. Rev.*, p. 4.
[2] Leuba: *Am. Jour. Psy.*, Vol. V, p. 382.

B. and G. (without distraction) that:—

With reagent G.,

Norm–h was judged "lower" 104 times or 23% of 'h.'
Norm–l was judged "higher" 35 times or 8% of 'l.'
Norm–h was judged "like" 43 times.
Norm–l was judged "like" 57 times.

With reagent B.,

Norm–h was judged "lower" 49 times or 12% of 'h.'
Norm–l was judged "higher" 66 times or 17% of 'l.'
Norm–h was judged "like" 38 times.
Norm–l was judged "like" 42 times.

In each reagent, therefore, the memory image must have drifted in each direction; in the case of G. with a prevailing tendency towards the higher end of the tone series, and with B. towards the lower end,—both reagents being wholly unaware of these processes. Now the nature of tone stimuli is such that we cannot adopt the elastic explanation advanced by Münsterberg in explaining similar results with shades of gray, *i. e.*, that the memory image faded either way according to the positiveness of the impression—a light shade being more positive for some reagents, and a dark shade for others. For in the series of tones judged by these reagents, reaching from 540 to 768 vibrations, it can hardly be said that one tone was more 'positive' than another, nor in the series of tone sensations is there the analogue of the assimilative and dissimilative processes which makes possible such an explanation as Münsterberg's. But according to the memory-image theory the above figures would indicate:—

1° That the memory image for G. faded more strongly towards 'low,' and for B. more strongly towards 'high.'

2° That the memory image of G. acquired such an impetus in fading, so to speak, as carried it beyond the region of 'likeness' more often than merely up to this region.

3° That the memory image of G. had different and opposing tendencies of fading according as the variable was like or unlike the norm.

An obvious explanation of the above figures is that G. simply miscalls perceived differences; he perceives the difference 'norm-high' but calls it 'lower.' But, as against this, in cases where we should expect to find any such tendency most pronounced—*i. e.*, in perceived differences of objectively like cases, the tendency, so far as it exists at all, is rather in the other direction. A discussion of this question will occupy us later on.

It may be said, and has been said, that the memory image neither increases nor decreases in size or intensity, nor changes in quality, but simply becomes dim and indistinct. If any intelligible meaning is to be given to these words, the result of

this growth in dimness and indistinctness would not be a larger liminal difference for the method of minimal changes, or a greater number of wrong judgments for the method of right and wrong cases, but rather a greater mean variation in the former method, and an increase in doubtful cases in the latter, and in both methods an increase in failures to judge at all.

Our tables, however, show no such result; L. who is the most accurate and S. the least accurate in judging objective differences, have the smallest number of doubtful cases. With A., who used the 'doubtful' category more often than any other reagent, we find, indeed, that the maximum number of "doubtful" judgments is with the 60-second interval, but on the other hand the 3- and 5-second intervals together evoke more doubtful judgments (12) than 30 and 40 seconds taken together (9).

Perhaps the simplest conditions for discussing this question are to be found in the case of toneless sounds, such as are given by the sound-pendulum, or better the fall-phonometer used by Starke in his experiments on the measurement of sound intensities.[1] Starke bases his explanation of the different results obtained in the time order on the fading memory image. "If the judgment is given," he says, "immediately after the impression of the second stimulus, the latter will be perceived in its immediate intensity, whereas the first sound being merely in the field of consciousness, can be compared only as a memory image with the second. But inasmuch as the memory image of weaker intensity as compared with the immediate impression, the influence of the time order must show itself in the over-estimation of the second sound.[2]" Turning to Starke's tables we find an extraordinary difference in the figures of the two time orders. Starting with positive or negative supraliminal differences Starke pushed the variable along, step by step, through the region of like judgments until a liminal difference was noted. Taking an 'ascending' variable, where the variable, at first noticeably weaker than the norm, is increased till it is like the norm, we find for three norms in the middle of the series investigated, the following differences

Intensity of Norm (mm.)	Intensity of Variable appearing like Norm (mm.)			
	REAGENT LT.		REAGENT LZ.	
	Time order N—Variable	Time order V—Norm.	Time order N—Variable	Time order V—Norm.
200	85	209	87	223
300	176	344	137	316
400	253	408	212	417

[1] Starke, Die Messung v. Schallstärken, Phil. Stud. III, S. 262.
[2] *Ibid.*, S. 290.

in time order.[1] From the above table we are to infer, therefore, that the memory image faded with such great rapidity in the time order norm-variable that the sound of a ball falling 200 mm. appeared no stronger after an interval of less than one second than that of the succeeding ball falling 85 mm., *i. e.*, the first sound must have lost about 57% of its original intensity. It further appears that when the time order variable-norm was used, the first sound faded comparatively slowly—so slowly that at the end of the time interval the variable 209 appeared like the norm 200; *i. e.*, the variable had 'faded' only to the extent of less than 5% of the norm. It might be said that in the second case the attention was directed more closely to the variable, *i. e.*, the first sound—than to the norm, and that therefore the former was held more strongly in the focus of consciousness. Martin and Müller have shown in experiments with 'hefted' weights, that a change in the direction of attention from the second to the first stimulus changes the tendency of judgments,[2] and it is not to be denied that some such influence may have been in play here, though it is not probable that the change of attention would have effected so great a difference as is indicated by the above figures. Starke himself gives no account of the attitude of his reagents in the two time orders, or indeed whether they were aware of the change in order, but in the figures which show the results of the descending gradations, *i. e.*, of the decreasing variable—we find conclusive evidence that the discrepancy in 'fading' in the two time orders is not due to a change in the direction of attention. From the same tables that gave the preceding figures, we take the results which Starke found by starting the variable somewhat louder than the norm, and then decreasing it till it appeared like the norm.

Intensity of Norm (mm.)	Intensity of Variable appearing like Norm (mm.)			
	Reagent Lt.		Reagent Lz.	
	Time order N—Variable	Time order V—Norm.	Time order N—Variable	Time order V—Norm.
200	169	394	160	387
300	279	578	256	582
400	374	747	352	744

In the case of reagent Lt. "like" for a norm of 200 was reached at a height of 169—indicating a comparatively small amount of fading. With the variable coming first, however, "like" for the same norm 200 is reached at a height of 394—

[1] *Ibid.*, S. 289.
[2] Martin and Müller: Analyse der Empfindlichkeit. S. 185–196.

a loss in intensity according to the hypothesis of 97% of the norm, so that in this case, if the attention was directed chiefly to the variable, it only served to accelerate its fading.

In strong contrast with Starke's results Kämpfe[1] found a very small time error for each of his two reagents. Moreover, whilst one reagent generally overestimated the second sound, the other underestimated it. Like Starke, Kämpfe worked with toneless sounds, though produced by the sound pendulum and not by the sound phonometer. Both investigations were carried out in the same room, and according to the memory image theory should have produced similar results. Kämpfe states the memory-image theory of the time error and suggests that the results, contradictory of the theory, may have been due to a strong fixation of the first sound.[2] He lays no weight on the explanation, however, but points out that the contradiction exists, and that the further discrepancy in his own judgments, where he passes from under to overestimation of the second stimuli, is not in disagreement with Fechner's experiments.[3] It was also found in the experiment on the method of mean gradations alluded to above (p. 61, note) that the two reagents showed contrary tendencies in estimating the position of the middle stimulus in the two time orders.

In the method of mean gradation or supraliminal differences, more perhaps than elsewhere, any theory of the comparison of impressions by means of the waxing or waning memory images becomes a tangle of absurdities. According to such a theory, in comparing three successive impressions, a, b, and c, we hold

NOTE. The explanation of the above discrepancies is to be found in a complication of factors which have themselves become subjects of psychological investigation, but which at the time these experiments were carried out [1883-1889] were hardly surmised. The influence of two of these factors, *i. e.*, the point of departure of the variable, and the size of the steps in a gradation method were subsequently pointed out by the writer, working under the same experimental conditions as obtained in Starke's research. [F. Angell. Unt. ü. d. Schätzung von Schallintensitäten, etc. *Phil. Stud.* VIII, S. 446-448.] Starke's tables give the impression that the point of departure for the variable, and the size of the 'steps' were closely proportional to the value of each norm used—conditions which would result in about the same number of judgments for all values of the norm. The writer would not here be understood as implying that such a procedure would invalidate Starke's results either as regards Weber's law, or the proportionality of sound intensity and height of fall, but it is to be inferred that the liminal values obtained by Starke (8 to 9 % of norm), hold good only for the particular conditions under which the experiments were performed.

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[1] Kämpfe: Beit. z. exp. Prüf. d. Meth. d. r. und f. Fälle. *Phil. Stud.* VIII, S. 562.

[2] *Ibid.*, S. 583.

[3] Fechner: *Psychophysik*, I, S. 90.

a and b first as memory images till c comes along, and then we compare the 'distance' a-b with b-c. In the first place there appears no reason why the memory-images of a and b should not coalesce; as they are supposed to exist simultaneously in the mind, they must coalesce. Supposing, however, they could be kept apart, we find that we have to compare the 'distance' a-b with b-c, when a-b is the distance between a remote and a near memory image, and b-c the distance between a near memory image and a present sensation.[1] But of all this complicated comparison of central and peripheral sensations, but little trace is to be found either by way of inference from the figures of the different time intervals, or directly from introspection. When three successive sounds, a, b, and c, are given at short intervals and b is judged 'nearer' a than c, the sound c seems in the moment of judgment no less a perception and no more a memory image than a—introspection usually failing to find any trace of imagery except perhaps a more or less disturbing visual scheme of the 'distances.'[2]

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[1] *Op. cit.*, S. 463.

[2] The term 'distance' is, of course, a figurative way of expressing degree of likeness or similarity. If the sounds a, b, and c are given, a and b coming from stimuli which are much nearer together than b and c, then we 'judge' that b is more like a in respect to intensity than like c, or figuratively, that the 'distance' a-b is less than b-c. It is to be observed that such a judgment can be given directly and immediately, without training and without reflection, by any one, child or adult, who is capable of discriminating between the sounds and holding them in mind. When, however, b moves towards c the difficulty in delivering a judgment increases, until it becomes exceedingly hard to say whether b is nearer a or c, or equidistant from both. This is a difficulty which is inherent in all psychophysical measurements and is not to be overcome either by experience or by reflection.

But besides this direct and so to speak, natural way of comparing three successive stimuli, Julius Merkel, in order to explain the discrepancy between his results and my own, has attributed to the reagents of my experiments, a power of comparing the several impressions according to their ratios, and this comparison according to ratio [Verhältniss] plays a most unimportant part in general in his explanation of results obtained by the method of mean gradations. Now it is obvious that the reagents could have given themselves over to comparing the three stimuli according to the arithmetical mean, geometrical mean, the golden mean, or any other ratio which they could have held in mind; but if introspection has any value as evidence, they did not. They started out in a series of experiments with the judgment that b, *e. g.*, was more like a in respect to intensity than like c; this is a direct and primary relation of similarity, and has no more to do with a comparison of intensity ratios than has the judgment that peaches taste more like apricots than like plums. In other comparisons, b seemed more like c than like a, and in some cases the reagents could not say whether b was more like c or like a in respect to loudness or intensity. Sometimes, not often, they had the conviction that b resembled a in respect to intensity just as much as it resembled c, or figuratively, that b was midway between a and c. These are the plain

In Bentley's[1] work on the optical memory image, the image was voluntarily produced as far as possible after a signal given just before the variable was exposed—the purpose of the research being an investigation of the qualitative 'fidelity' of the voluntarily aroused central ideas. But even under these conditions it was found that 'free' judgments, *i. e.*, judgments in which introspection failed to find a trace of comparison with a memory image, were given quickly and with a feeling of considerable security. The memory image itself Bentley found more easily producible at the end of five minutes than of one minute.

In Radoslawowv's investigation on memory for lines we find a good example of the elasticity of the memory-image theory. In the earlier part of Radoslawowv's extended research he asserts, very emphatically, that it is impossible for the attention to be directed during the time interval to the memory image, as the image is rarely present, and when present, is indistinct.[2] But further on, as has been already remarked (p. 68), we find R. explaining the more accurate results obtained when the time intervals were filled with some distracting occupation, on the hypothesis

facts in the case, and if Merkel desires to call this way of comparing, a comparison by ratios, he is of course free to do so. But if by this he means that the reagents tried to compare the stimuli in such a way that a should be to b, as b to c, I am bound to say, first, that the reagents gave themselves over to no such artificial scheme, and secondly, had they done so the results could not have been regarded as valid any more than Merkel's own results with his method of double stimuli—and for the same reason,—they would have been the outcome of reflection and inference from experience. As regards Merkel's remarkable assertion that I found the geometrical mean of the stimuli because I had to find it (*Phil. Stud.* X, S. 212), I am free to say that beyond a slight weakness for the arithmetical mean because it is easier to calculate, I find in myself no marked tendency towards either mean—assuredly no such compulsive force as would have driven me for about 2 years through the not highly exhilarating exercise of dropping ivory balls on ebony plates in a hunt for a geometric mean. Why, if Merkel felt that from the first the work was predestined to the state of the geometric mean, he should have given so many pages to combating it, is not clear to me. Inasmuch as Merkel's objections are partly errors of comprehension, and mostly matters of small psychological moment, I have not thought that psychological research would be benefited by a detailed discussion of them. The main question at issue in the controversy is one of method, and to such psychologists as have the patience to wade their way through Merkel's investigations and my own, I am more than willing to leave the decision as to the way in which trustworthy results are more likely to be obtained—from a series of regularly graded stimuli which the experimenter presents to himself as reagent, or by an irregular series presented to reagents who have no knowledge either of the objective value of the stimuli, or of the trend of results.

[1] Bentley: The Memory Image and its Qualitative Fidelity, *Am. Jour. Psy.*, XI, p. 1.

[2] *Op. cit.*, S. 355.

that during the empty intervals the memory was 'dulled' by the incessant reproduction of the normal line, just as the memory image of a face fades the more, the longer the attention is directed to it.[4] On p. 396 again, we find that the inaccuracy resulting from introducing a distracting line between norm and variable is referred to the expunging of the memory-image of the norm by the intermediate line. In general, however, in these experiments of Radoslawowv, the writer is of the opinion that what has been investigated is not the 'sharpness' of memory for lines but rather the accuracy of comparison under circumstances of increasing difficulty, *i. e.*, increased intervals of time. For in the table which give the results of R.'s experiments with the method of minimal changes, we find that two of the three reagents (F. and E.) showed an increase in liminal difference values for the upper limina, for an increase in time interval, but failed to show any corresponding increase in the mean variation; in both cases the mean variation indicated small and irregular fluctuations. We are able to form no intelligible theory of comparison through an act of memory which would explain such figures; waxing or waning, fading or brightening of the first impression would all have given different results from the above. But similar results could have been obtained had the reagents compared simultaneously lines placed at increasing distances from one another. In such a case the liminal differences would have increased with the increase in distances between the lines exposed; and had the reagents waited till they felt the same degree of security for each liminal difference, the result would have a small and irregular fluctuation in the mean variation. They might, however, have recorded their first more or less insecure impression of a liminal difference; in this case the liminal value would not show much growth, but the mean variation would increase with the difficulty in comparison. This condition actually obtains in the lower liminal values for the two reagents F. and E. The writer regards this only as a possible explanation of these contradictory results; but the conventional scheme of memory comparison is here impossible. Experimenting on himself and using the method of right and wrong cases, Radoslawowv found in general a decrease in right judgments along with increase in time interval; for the time intervals running from 1 sec. to 13 sec. the decrease in right judgments was 65.3 to 46.3%.[1] For the same range of time intervals, *i. e.*, 1 to 15 seconds, Wreschner, using an irregular method of minimal changes, found little or no falling off in sensitiveness to differences for linear distances.[2] So far as such results concern the conventional scheme of sensory memory

[1] *Ibid.*, S. 366.
[2] *Op. cit.*, S.339.
[3] Wreschner: Meth. Beit. z. psychophys. Messungen, S. 231.

they are, of course, contradictory, but so far as they indicate the varying influences of different psychophysical methods they are in themselves interesting subjects for psychological investigation.

The writer has gone at some length into the memory-image theory of comparison because he considers that it has had an exceedingly harmful influence on psychological research. As Külpe says:[1] "It is remarkable that this theory should have maintained itself up to the present time, whilst the contradiction in which it involves the facts of experience, as well as any consistent explanation of these facts, have rarely been noticed." It was unfortunately launched with all the impetus that comes from Fechner's authority, though Fechner seemed well aware of its contradictions, and it still continues to glide along over logical inconsistencies and psychological absurdities. Its powers of adaptation are shown in Wreschner's argument against Külpe that although we are not aware of the presence of the memory image of the earlier impression in an act of comparison, "still the first impression can be regarded as artificially held in remembrance and passing over into the second, when it undergoes a change which can be regarded as the source of the time error.[2]" If it be objected that in this article, the fading or waning of the memory image has been interpreted in too much of a physical sense, it is to be replied, that this is precisely the trouble with the theory—it is a concept derived from physical processes with physical implications on which have been grafted the determinations of the psychophysical measurements, the outcome of which has been barren of all results for psychology.

An example of what an elastic memory-image theory with physical implications can accomplish is to be seen in Warren and Shaw's "Memory for square size[3]" in which we find not only a fading memory image, but a play of imagination images taking place according to the laws of chance, and under the dominating influence of Weber's law—which process goes on until the 'average imagination image' usurps the function of the memory image and brings about an overestimation of the norm. But of all this complication of waxing and waning, of fading and brightening of memory images, introspection has found but scanty trace, and when as in the case of optical stimuli the memory image occasionally appears, it has yet to be shown that it increases the accuracy of comparison in so-called memory experiments any more than the possession of an absolute memory for pitch increases discriminative sensibility for tones.[4]

[1] Külpe: Phil. Monatsh., XXX, S. 282.
[2] *Op. cit.*, S. 173.
[3] Psy. Rev. II, p. 241–243.
[4] Vid. v. Kries, Ueb. d. absolut. Gehör, Z. f. Psy. III, S. 262.

THE APPERCEPTION OF THE SPOKEN SENTENCE: A STUDY IN THE PSYCHOLOGY OF LANGUAGE.

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I.

INTRODUCTION.

Despite the important rôle which it plays in the mental life, language has, until recently, received but scant attention from the psychologist. While all have recognized the significance of language both as a medium for the transmission of experience,[1] and as the precondition of the higher 'intellectual' processes,[2] very few have attempted a detailed analysis of the verbal idea, and only within a few years has the psychophysics of verbal expression and verbal perception been adequately exploited. It is true that some of the Herbartians, especially Lazarus[3] and Steinthal,[4] have given the discussion of language an important place in their psychological systems, and it is true that the English school—Hartley,[5] Locke,[6] and James Mill[7] in particular—have made much of the function of the word in conceptual thought. But the Herbartian treatment of language was limited to the part which verbal symbols played as the condensed representatives of the Herbartian 'Ideas;' and the English treatment of language belongs rather to logic and epistemology than to psychology. In the

[1] Wundt, W: Grundzüge der physiologischen Psychologie. Leipzig, Vol. II, pp. 610 ff. James, W.: Principles of Psychology. N. oo, Vol. II, pp. 356-358. Hoefler, A.: Psychologie. Wien und 897, pp. 537 ff.

[2] d, G. T.: Psychology, Descriptive and Explanatory. N. Y., p. 379 ff. Sully: Outlines of Psychology. London, 1885, pp.

[3] arus, M.: Das Leben der Seele. Berlin, 1878, pp. 213 ff.

[4] nthal, H.: Einleitung in die Psychologie und Sprachwissen- Berlin, 1881, pp. 290 ff.

[5] tley, D.: Observations on Man, 4th ed. London, 1801, pp.

[6] :e, J.: An Essay Concerning the Human Understanding. Ox- 94, Vol. II, Book iii.

[7] J.: Analysis of the Phenomena of the Human Mind. 2d ndon, 1878, pp. 127 ff.

earlier literature of the experimental school, the phenomena of language are strangely neglected. The early studies on the association of ideas used the word as a convenient instrument of experimentation, and the related work upon reaction times involved many of the psychological and physiological principles of vocal expression as well as the psychophysics of symbolic perception; but in neither of these instances was language the primary interest. And yet, notwithstanding this early neglect, there has within the past decade been a very promising growth of monographic literature devoted solely to the psychophysics of language as such. If this growth continues at its present rate, the time will come within a very few years when this literature, together with the philological and pathological studies bearing upon the same problems, must be condensed and classified into a true psychology of language. The time is, of course, not yet ripe for such a systematic treatment, but in lieu of the guide which it would afford, the following very brief enumeration of the fields which such a compendium must cover may serve to introduce our own problem, and to give it the advantage of an orientation which, even if tentative and inadequate, will at least be logical.

The general psychology of language divides itself logically into two great sections: (1) the psychology of language considered as the preconditioning mechanism of the higher mental processes; and (2) the psychology of language considered as the medium of communication, through the agency of which experience is transmitted from individual to individual. To the first section belong the introspective studies and analyses of the verbal idea, its composition in terms of sense-modalities and its function in 'thought.' The monographs of Stricker[1] and of Raymond Dodge[2] are examples of the work which will fall under this rubric. The second section includes the great mass of material which deals with word-perception, the psychological unit in reading, speech development, and the phenomena of aphasia, all of which will fall within one or other of two subsections: (a) the psychology of symbolic expression; and (b) the psychology of symbolic interpretation.

The former subsection deals with the conscious processes that are correlated with the expression of symbols, either by gesture, by manual signs, by writing or by speech. It is manifestly a department of the psychology of action, but its problems have hitherto been treated mainly by the genetic or

[1] Stricker, S.: Studien uber die Sprachvorstellungen. Wien, 1880.
[2] Dodge, R.: Die motorische Wortvorstellungen. Halle Dissertation, 1896.

by the pathological method. Among the genetic studies of expression, the work of Baldwin,[1] Preyer,[2] Perez,[3] Schultze,[4] Noble,[5] Kirkpatrick,[6] Tracy,[7] and Lukens[8] furnishes valuable data regarding the ontogenesis of speech. These data must, of course, be verified and supplemented by further observations, and finally interpreted in the light of some comprehensive theory of mental development. In connection with the pathology of expression, the work of Wernicke, Grashey, Lichtheim, Freud, Hughlings-Jackson, Kussmaul, Exner, Charcot, Déjérine, Bastian, Starr, and Elder is too well known to require especial mention. Many of the monographs are already classics in the literature of psychiatry. A general summary of their results, however, interpreted from a psychological rather than from a clinical standpoint, has long been wanting. Perhaps the most satisfactory attempt to fill this want is represented by Joseph Collins's recent work.[9] Bawden's monograph,[10] dealing as it does with the border-line between normal and abnormal expression, will also find its place in this subsection.

The latter subsection—the psychology of symbolic interpretation—deals with the conscious processes that are correlated with the perception of symbols and the apperception of their meaning. It is to this chapter of the psychology of language that the present study belongs. It represents an attempt to determine the nature and relations of the factors which are involved in the perception of spoken symbols and in the apperception of their meaning. Inasmuch, however, as the study was suggested by recent investigations upon the psychophysics of visual perception, a general discussion of the factors involved in any form of symbolic perception, as well as a brief review of these other investigations, will not be out of place.

If we consider symbols apart from their 'meaning' and look

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[1] Baldwin, J. M.: Mental Development in the Child and the Race.

[2] Preyer: Mind of the Child. Trans. Brown. N. Y., 1888. Mental Development of the Child. Trans. Brown. N. Y., 1893.

[3] Perez, B.: The First Three Years of Childhood. Trans. A. M. Chicago, 1895.

ltze, F.: Die Sprache des Kindes. Leipzig, 1880.

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atrick, E. A.: How Children Learn to Talk, etc. *Science*, 1.

F.: The Psychology of Childhood. Boston, 1895.

s, H. T.: A Preliminary Report on the Learning of Lan- *edagogical Seminary*, Vol. III, pp. 424-460.

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len, H. H.: A Study of Lapses. *Psychological Review* *ph Supplement*, Vol. III, No. 4 (Whole No. 14), April, 1900.

at them simply as different forms of stimuli appealing to one or another of the sense-departments, it is manifest that certain psychophysical principles condition their efficiency for perception. (1) The symbols must over-step the spatial, qualitative, temporal and intensive limina of the sense-department to which they appeal; and (2) the symbolic elements must overstep the differential limen of the modality to which they belong, *i. e.*, they must, as perceptive elements, be discriminably different. In the ordinary visual symbolism, these differences are spatial,—differences of form, of spatial extent, of spatial position. In the typical auditory symbolism—speech—the differences in the expressive stimuli are more complicated. They are (1) a qualitative difference, (2) a temporal difference (both of which may be called primary differences), and (3) an intensive difference (which is more or less secondary in its nature). In more concrete terms, the differences in the symbolic elements appealing to the ear are: (1a) in the case of consonants, modal differences of a complex nature due to the different forms of adjustment and release of the various parts of the vocal apparatus concerned in the production of consonants; (1b) in the case of vowels, simpler qualitative differerences due to the modifications of the laryngeal clangs by the changes in the form of the pharynx and the buccal cavity; (2a) temporal differences within the complex temporal unit of expression (rhythm); (2b) temporal differences in the rapidity with which one symbol element succeeds another symbol element (quantity and pause); (3) intensive differences, due to the fact that certain symbol elements may be emphasized and that the innervation for certain other symbol elements may be weakened.

It is evident that a psychophysical examination of the conditions underlying the perception of symbols must proceed along the lines marked out by an analysis similar to that given above. One of the problems of such an investigation would be the determination of the value of each of these factors in word and sentence perception. This we find to be the point of view of those who have recently approached the study of language from the psychophysical side. They have consistently held to the problem of perception, and they have treated this problem according to psychophysical methods. This work has, however, been confined almost exclusively to visual perception, and the majority of monographs that have been produced are studies in the psychology of reading.

Cattell[1] made the first important experimental determination of the time required for the perception of letters and words. His prin-

[1] Cattell, J. McK.: Ueber die Zeit der Erkennung und Benennung, etc. Phil. Studien, Vol. I, pp. 635 ff.

cipal conclusions are as follows. (1) The maximal rapidity with which a word can be read, when given in a context, varies directly with the subject's knowledge of the language to which the word belongs; (2) if the words do not form sentences, and the letters do not form words, the time required for reading them is approximately doubled; the time required for the perception of a letter is very little shorter than that required for the perception of a word; (3) the less familiar a word is, the smaller is the difference in the time required for reading it backwards and reading it forwards.

During the same year in which Cattell made these determinations, Grashey[1] published a paper, based upon a study of aphasia, in which he maintained that the unit of perception in reading was the letter and not the word. This position was adopted by Wernicke, Leube and other alienists. Loewenfeld,[2] six years later, basing his conclusions also upon aphasic observations, affirmed that with the practiced reader the operation was not literal but verbal. He supported this observation by experiments with blurred words, in which he found that when the words were familiar a considerable amount of blurring did not interfere with the perception, while quite the opposite obtained with unfamiliar words. Goldscheider and Mueller[3] subjected this problem to an elaborate experimental treatment. They found the time of perception to be dependent (1) upon the number of elements, and (2) upon the uniformity of their arrangement. In the case of elements of different kinds, the type or plan of arrangement was much more easily perceived than the separate characteristics of the single elements. In the exposure of letters which did not form words, the following results were obtained. (1) Four letters were correctly perceived upon the first exposure; (2) five letters were always correctly seen upon the second exposure. As regards letter-series forming syllables, words, and word-groups, it was found that series of four letters were correctly read at the first exposure; more than four letters were not successfully read at the first exposure, unless they were quite familiar. If the entire word is not perceived, there is a tendency to fill out the perceived letters into any word that may contain them. In words of eight letters or more, more than one exposure is invariably required. While only eight letters can be perceived in .03 sec., three words that make connected 'thought' can be correctly perceived in the same time. In actual reading, letters are either of 'determining' or of 'indifferent' significance for perception. To the former category belong in general the consonants and especially the initial letters. General conclusions: (1) In ordinary reading, there is no reason to believe that each letter is perceived as such. (2) For the production of the verbal (auditory-kinaesthetic) idea, and for the purposes of conceptual 'apperception,' the percep-
[illegible] the total number of letters uniting to form the word is not
[illegible] perception of certain determining letters being suffi-
[illegible] purposes. (3) It is probable that the determining
[illegible] phonetic letter-sound images corresponding to them,
[illegible] in turn evoke the complete verbal (auditory-kinaes-
[illegible]) The word-image procedure in reading is not to be
[illegible] 'literal' reading by the perception of 'determin-
[illegible] word-image is the succession of letter images.

[illegible] Aphasie und ihre Beziehung zur Wahrnehmung. Archiv [illegible]ankheit, Vol. XVI. (1885.) pp. 654-689.

[illegible] zwei Fälle von amnestischer Aphasie, etc. Deutsche Zeit-[illegible]kunde, Vol. II. I Heft.

[illegible] und Mueller, R. F.: Zur Psychologie und Pathologie des [illegible] klinische Medicin, Vol. XXIII, pp. 130-167.

'Reading in word-images' is, therefore, in reality a reading in letter groups.

Pillsbury's problem[1] was in many respects closely related to that of Goldscheider and Mueller. He attempted to determine the "relative importance of sensation and the more general and remote factors which are involved in the very simple and familiar operation of reading a word." The method employed was the mutilation of type-written words by omitting, blurring and substituting letters. Results: (1) The various kinds of changes made in the words stand in ease of recognition in the following order: omitted, substituted, blurred. (2) A disfigurement of the first letter is easily recognized, but disfigurements coming later are apt to be overlooked. (3) Where more than one letter is disfigured the first disfigurement is not so often overlooked as are the others. (4) There is about as much chance of recognizing a misprint when it stands alone as when others are combined with it in the same word; if there is any difference, it is in favor of recognizing a change when others are present. (5) The strength of suggestion which comes from the word itself is entirely independent of the length of the word. (6) The proportion of misprints overlooked is greatly increased under the influence of the suggestion of associated words.

Erdmann and Dodge[2] consider Goldscheider and Mueller's results untenable. (1) Words are optical wholes, but the spoken reproductions are letter combinations. (2) If a printed line (the context of which may be readily understood) is read, and the head meantime kept in an immovable position, there is a regular alternation between the pauses of rest and the eye movements. The number of movements is much smaller in reading the mother-tongue than in reading a foreign language; and the more familiar the context, the more uniform are the durations of the rest-pauses and the movements. (3) The number of rest-pauses and movements is three times as great when the reader attends to the text itself as when he attends to the contents of this text. (4) When the attention is directed upon the text, rather than the contents, the field of most distinct vision includes about four letters (p. 68). (5) The rapid alternation of the black and white text-elements following one another during the eye-movements completely excludes the possibility that we cognize the letters in the course of such movements (p. 71). During the course of the eye-movement in reading there is lacking a perceptive contents corresponding to the actual stimuli presented by the letters, if, as is ordinarily the case, the attention is not directed to this perceptive contents. (6) Visual perception of the letters in reading occurs exclusively during the rest-pauses of the eye; these can, therefore, be designated reading-pauses. The areas of simultaneous perception in reading are greater than the areas of distinct perception of the single letters, and the range of these reading-areas excludes the possibility that all single letters contained in them are distinctly perceived. The sum total of the visual angles subtended while reading a line is smaller than the visual angle for the entire line. (7) Under similar conditions, four to five times as many letters can be read in word-connection as without word-connection. In the reading of letters exposed without word-connection, the last to be exposed are generally either not read at all or falsely read. (8) The fact that we perceive familiar words under conditions that exclude any perception of the single elements is due to the typical forms which the words

[1] Pillsbury, W. B.: The Reading of Words. This *Journal*, Vol. VII, pp. 315 ff.
[2] Erdmann, B., and Dodge, R.: Psychologische Untersuchungen ueber das Lesen auf experimenteller Grundlage. Halle, 1898.

II.

Experiments.

(A) The Perception of Auditory Symbols: (1) The Relation of the Objective to the Subjective Factors of Auditory Symbolism; (2) The Relation of the Objective Factors to One Another.

§ I. *Method and Apparatus.* The method employed in the first two determinations was based upon the psychophysical principles we have already laid down. A word is normally a definite complex of various sounds which we call consonants and vowels. As we have seen, the consonantal variations are modal changes conditioned by the different forms of adjustment and release of the vocal organs. The vowel variations are qualitative modifications of the laryngeal clangs. A consonant always involves a vowel; hence, if we vary the consonants, we also vary the vowels. Our method involved the elision of consonants, and a determination of the accompanying effect of the word upon the observer. In order to determine the relation of the psychophysical factors to the central factors (the first and primary problem), (a) mutilated words were given without context, (b) mutilated words were given with a minimum of context, *i. e.*, with one or two related words, (c) mutilated words were placed at the beginning of complete sentences, (d) mutilated words were placed in the middle of complete sentences, and (e) mutilated words were placed at the end of complete sentences. In order to determine the value of the symbolic elements as compared with one another, *i. e.*, the relation of the objective factors to one another (the second problem), the effects of the various forms of mutilation upon the perception of the word by the observer were compared. In this case the words were used with and without context, the temporal conditions being varied by eliding consonants (a) at the beginning of the word, (b) in the middle of the word, (c) at the end of the word.

The words thus mutilated were divided into the following categories:

I. Initial consonant omitted. Class A.

II. Mid-consonant omitted. Class B.

(1) The consonant standing alone between two vowels.

(2) The consonant standing next to another consonant,—so, *i. e.*, that a voiceless hiatus should not be left between the vowels upon elision.

III. Final consonants omitted. Class C.

These words were placed in short, complete and categorical sentences, which were classified as follows:

I. Sentences in which the mutilated word is at or near the beginning. Class *a*.

II. Sentences in which the mutilated word is in the middle. Class *b*.

III. Sentences in which the mutilated word is at the end. Class *c*.

There were thus possible the following series of sentences:

Aa. Initial consonant omitted at the beginning of the sentence.
Ab. Initial consonant omitted in the middle of the sentence.
Ac. Initial consonant omitted at the end of the sentence.
Ba. Mid-consonant omitted at the beginning of the sentence.
Bb. Mid-consonant omitted in the middle of the sentence.
Bc. Mid-consonant omitted at the end of the sentence.
Ca. Final consonant omitted at the beginning of the sentence.
Cb. Final consonant omitted in the middle of the sentence.
Cc. Final consonant omitted at the end of the sentence.

Of these possible combinations, the following were selected as answering every demand of the experiment:

Aa, Ac, Ba, Bc, Cb, Cc.

It was attempted to make every series complete, *i. e.*, to represent every consonant in every series. For purposes of convenience a classification of consonants, following in the main that of Whitney,[1] was tentatively adopted:

	Semi-vowels.	Aspirates.	Nasals.	Sibilants.	Spirants.	Mutes.
Labials	w		m		v, f	b, p
Linguals	r, l		n	z, s	th, ch, j	b, t
Palatals	y	h	ng	zh, sh		g, k

It was also attempted to combine every consonant with every vowel; *i. e.*, to represent each consonant in every series by as many different words as there are different vowel sounds. When this could not be done, different words were added in which the consonant in question was preceded or followed by a vowel already in use in another word.

The following complete series (Bc) is inserted as an example:

1. As a companion he was extremely a(m)iable.
2. The howling wind set the windows rattling and the doors sla(mm)ing.
3. The religious spirit is predominantly e(m)otional.
4. It is often hard to reduce a compound to its ele(m)ents.
5. A light on the distant shore was gli(mm)ering.
6. As a [illegible] the poet was forever rhy(m)ing.
7. He [illegible] have loosened the knot in another mo(m)ent.
8. The [illegible] refused a new no(m)ination.
9. [illegible]ward where the mountain was loo(m)ing.
10. [illegible] life cannot be wrecked by calu(mn)y.
[illegible]asperating being on earth is a coquettish wo(m)an.
[illegible] little band of men he was the bra(v)est.
[illegible]ystery that none of us could unra(v)el.

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[1] [illegible] W. D.: Life and Growth of Language. N. Y., 1885.

14. It was admitted to be a glorious achie(ve)ment.
15. He did not deny the possibility of divine re(v)elation.
16. Amusement was furnished in great di(v)ersity.
17. Every man possesses an element of the di(v)ine.
18. He stopped to take breath when he reached the ri(v)er.
19. It was rumored that the war was o(v)er.
20. We knew that he could not reco(v)er.
21. The circuitous route is the sa(f)er.
22. When we saw her she was lau(gh)ing.
23. The captain wore a heavy ree(f)er.
24. I had never seen him be(f)ore.
25. The concussion was dea(f)ening.
26. He was known as an ignorant sco(ff)er.
27. It is wrong that the innocent should su(ff)er.
28. Gluttony is an euphemism for stu(ff)ing.
29. He loved all animate things except ba(b)ies.
30. The word was not in the voca(b)ulary.
31. I had often witnessed the scene he had just been descri(b)ing.
32. He was held for murder and ro(bb)ery.
33. The ring was set with ru(b)ies.
34. The floor needed a good scru(bb)ing.
35. His painting might better have been called dau(b)ing.
36. As a mechanic he was extremely ca(p)able.
37. One cannot deny that the office-holders are ra(p)acious.
38. No one doubts the moral efficacy of re(p)entance.
39. The flocks were watched by she(p)herds.
40. The wire was quickly cut with a pair of ni(pp)ers.
41. Some one cut the rope he was gri(pp)ing.
42. The bank was slo(p)ing.
43. I caught the words he was dro(pp)ing.
44. It was the work of the little god Cu(p)id.
45. Blame no man for his stu(p)idity.
46. The structure was simply stu(p)endous.
47. His position on the question was a(n)omalous.
48. The panic was ge(n)eral.
49. He had lost everything except his ho(n)or.
50. The ship could be located by the smoke from her fu(nn)els.
51. The hedge needed pru(n)ing.
52. Such a contingency was extremely fortu(n)ate.
53. I could see that he was frow(n)ing.
54. The results were most ama(z)ing.
55. The water in the pipes was free(z)ing.
56. There was some question as to the re(s)ults.
57. One must act quickly and without he(s)itation.
58. She did not like ro(s)es.
59. He was unable to maintain his po(s)ition.
60. He left the game when he found that he was lo(s)ing.
61. He had left word that he would be extremely bu(s)y.
62. Are you acquainted with that ponderous tome which he is peru(s)ing?
63. The yacht was intended for ra(c)ing.
64. The book was put a(s)ide.
65. The degenerate is marked by his a(s)ymmetry.
66. His time was spent in re(s)earch.
67. We made the preparation according to the re(c)ipe.
68. We were to travel through Europe on bi(c)ycles.
69. The empire included all Chri(st)endom.
70. He was a victim of hallu(c)inations.

71. We do not think that the combination is po(ss)ible.
72. The situation was highly amu(s)ing.
73. He was not aware of the storm he was arou(s)ing.
74. The problem of natural science is the interpretation of na(t)ure.
75. Contagious diseases are those which are called ca(tch)ing.
76. The reverend gentleman was a popular prea(ch)er.
77. On the wall hung a painting and two e(tch)ings.
78. For conquest he had a strange i(tch)ing.
79. We did not see the train approa(ch)ing.
80. The beef trust is hard on the bu(tch)er.
81. By his side the dog was crou(ch)ing.
82. Diseased tissues are studied by the pa(th)ologist.
83. War clouds are ga(th)ering.
84. He went into business with his fa(th)er.
85. Good speaking depends on good brea(th)ing.
86. The horses wait wi(th)out.
87. He had been shot through the head and lay on the ground wri(th)ing.
88. Many of the soldiers were without proper clo(th)ing.
89. It was not the difficulty that bo(th)ered.
90. The loss was next to no(th)ing.
91. The fire was almost smo(th)ered.
92. His death must be reported to the au(th)orities.
93. The illumination is ra(d)iant.
94. The pain was almost ma(dd)ening.
95. The statement is utterly incre(d)ible.
96. The train was backed upon a si(d)ing.
97. The men had left the car they were loa(d)ing.
98. The lawn needed so(dd)ing.
99. I saw the book which he stu(d)ied.
100. They did not know the trouble over which he was broo(d)ing.
101. He was evicted as an intru(d)er.
102. He was seen in Paris ten days la(t)er.
103. The governor refuses to discuss the ma(tt)er.
104. On his part the attitude was confessedly a pre(t)ense.
105. We counted on the rose five pe(t)als.
106. He is a good wri(t)er.
107. The leaders admitted that they could not meet the extremi(t)y.
108. We were to have gone boa(t)ing.
109. The tree is swaying and to(tt)ering.
110. The crowd was jeering and hoo(t)ing.
111. A man must earn his bread and bu(tt)er.
112. She was divinely beau(t)iful.
113. The project has been extensively exploi(t)ed.
114. The army was completely rou(t)ed.
15. The window was reset by a gla(z)ier.
6. The color of the sky was a(z)ure.
7. We do not get much lei(s)ure.
. One does not live for plea(s)ure.
. We waited within the enclo(s)ure.
. The Poggendorf figure is an optical illu(si)on.
. He did not welcome our intru(s)ion.
. The matter interests the entire na(ti)on.
His pleading was fiery and pa(ssi)onate.
Several connoisseurs expressed their appre(c)iation.
We have already signed the peti(ti)on.
The life we lead is not real but facti(ti)ous.
Before us stretched the expanse of the o(ce)an.

128. The ballot is not free from pollu(ti)on.
129. The moment was cru(ci)al.
130. We were almost stunned by the concu(ssi)on.
131. Proceed along the path with cau(ti)on.
132. The most entrancing theories are the va(gu)est.
133. We had experienced the awful a(g)ony.
134. The king knew that his courtiers were intri(gu)ing.
135. He had killed lions and bears and ti(g)ers.
136. The army was made up of volunteers and re(g)ulars.
137. The lad had climbed into the ri(gg)ing.
138. The children were ro(gu)ish.
139. The ant tendered a reception to the slu(gg)ard.
140. The play was characterized by its unique sta(g)ing.
141. The affair is too horrible to ima(g)ine.
142. The criminal presented many marks of de(g)eneration.
143. The strips were used for e(dg)ing.
144. We found him most obli(g)ing.
145. He was not dogmatic in his reli(gi)on.
146. The term 'education' is preferred to 'pedago(g)y.'
147. We did not see him at his lo(dg)ing.
148. Industry without art is dru(dg)ery.
149. He was a notorious pu(g)ilist.
150. We bought bread of the ba(k)er.
151. The enterprise did not lack ba(ck)ers.
152. Death is followed by de(c)ay.
153. We are at the end of a de(c)ade.
154. Eric was one of the Vi(k)ings.
155. The fires are fed by an automatic sto(k)er.
156. There was plenty of food in the lo(ck)ers.
157. He got a good du(ck)ing.
158. I do not like him any lo(ng)er.
159. We heard that she was a good si(ng)er.
160. The evening chimes were ri(ng)ing.
161. The man was leaning over the rai(l)ing.
162. We had visited the pa(l)ace.
163. I did not know his fee(l)ing.
164. The missionary was most zea(l)ous.
165. It is called latter-day Phi(l)istinism.
166. All sciences have grown out of phi(l)osophy.
167. The people are not civi(l)ized.
168. We took our exercise by bow(l)ing.
169. The coat had a velvet co(ll)ar.
170. He chided him for his foo(l)ishness.
171. The procedure was acknowledged to be irregu(l)ar.
172. He is blind to certain co(l)ors.
173. The disaster is appa(ll)ing.
174. The water is improved by boi(l)ing.
175. The wind was how(l)ing.
176. The law is subject to many va(r)iations.
177. I have not a word against his private cha(r)acter.
178. We were among her admi(r)ers.
179. The procedure was most i(rr)egular.
180. Do not always look for the mo(r)al.
181. They came away much poo(r)er.
182. His hesitancy is natu(r)al.
183. Mrs. Smith was to do the pou(r)ing.

Theoretically, the sentences numbered in all 1085, but owing to the difficulty encountered in finding words for all classes, as

well, Dr. G. M. Whipple, Dr. W. B. Lane, Miss F. M. Winger, Miss J. A. Cochran, Mr. H. O. Cook, and Mr. R. M. Ogden. While the nature of the experiment necessitated a certain amount of knowledge on the part of the observers regarding the work in hand, the special object of the tests was unfamiliar to them, and the general procedure may be designated as 'without knowledge.'

It will be readily seen that the use of every possible combination as given above (p. 88) would introduce into the experiment a source of error which must, as far as possible, be avoided. The words were first given alone, and then repeated once or twice with a contextual connection. By permitting a relatively long interval of time—two to four months—to elapse between each repetition of the word in the various connections, the recognition of the word as having occurred in a previous test happened very infrequently. Had every combination been used for each word, such a procedure would have been quite impossible.

§ 3. *Results and Conclusions.*

PROBLEM I. THE INFLUENCE OF CONTEXT UPON THE PERCEPTION OF AUDITORY SYMBOLS.

In this connection we have to compare the results of giving mutilated words alone, of giving them with a minimum of context, of giving them at the beginning of complete sentences, of giving them in the middle of such sentences, and of giving them at the end of such sentences.

(a) *Words Given Without Context.*

Table I shows the percentage of mutilated words correctly perceived when given without context. The letters A, B and C refer to the place in the word at which the elision was made —A, initial consonant elided; B, mid-consonant elided; C, final consonant elided.

TABLE I.

Class.	Total No. Judgments.	Right.	Wrong.	Perc't R't.
A	260	9	251	3.5
B	450	189	261	42.0
C	260	34	226	13.0
Totals,	970	232	738	23.9

The relatively high number of right judgments in the B-series is probably due, in large measure, to the fact that where the mid-consonants are omitted the words are predominantly polysyllabic. The A and C series were entirely monosyllabic. With this difference, the B-series should, of course, be left out of any comparison. The following conclusion seems to follow from the Table:

1. *In monosyllabic words the elision of the initial consonant affects perception more than the elision of the final consonant.*

This conclusion is in substantial agreement with Pillsbury's results for printed words: "A disfigurement of the first letter was easily recognized, since there was but slight expectation of what was to come."[1] The fact also suggests Goldscheider and Mueller's conclusion that the initial letters are among the predominantly 'determining' elements in reading,[2] as well as Huey's conclusion regarding the importance of the first part of the word in perception.[3] The fundamental rôle which the initial consonants play in the genesis of speech is illustrated by the fact that the first consonants which the child uses are initial, and that only initial consonants are used for some time.[4]

(b) *Words Given with a Minimum of Context.*

The words used in this determination were chosen from the B-series. A complete record of one observer is given below.

		Observers' Report.	
Mutilated Word.	Context.	Word Alone.	With Context.
A			
A(m)iable	friend, cherished	a(m)iable	amiable
Sla(mm)ing	doors, childhood	slatting	slammed
E(m)otional	elements, determine	e(m)otional	e(m)otional
Gli(mm)ering	guided, light	query	twinkling
Ele(m)ents	water, hydrogen	eloquence, elegant	ele(m)ents
Rhy(m)ing	adolescence, instinct	riding	rising
Mo(m)ent	caught, flies	owen	woman
No(m)ination	his, assured	darnation	nomination
Loo(m)ing	up, Mt. Washington	bluing	loo(m)ing
Calu(mn)y	him, heaped	calumny	calumny
Wo(m)an	bundle, foibles	one	one
Bra(v)est	men, fear	brayers	brave
Ca(v)il	calumny, unscathed	hal	cavil
Achie(ve)ment	little, criticism	achie(v)ement	achievement
Re(v)elation	universe, interpreted	revelation	revelation
Di(v)ersity	interest, friendship	diversity	diversity
Di(v)ine	interference, human	decline	divine
O(v)er	divide, land	or	war

[1] Pillsbury: *op. cit.*, p. 350.
[2] Goldscheider and Mueller: *op. cit.*, p. 160.
[3] Huey: This *Journal*. Vol. IX, p. 581.
[4] Tracy: The Psychology of Childhood, p. 127.

Mutilated Word.	Context.	Observers' Report.	
		Word Alone.	With Context.
No(v)el	force, life	now	doll, shall
Pro(v)ing	error, process	cooing cooling	accruing
Lo(v)able	women, courtesy	gavel garbel	lovable
Lau(gh)ing	leads, obesity	thine	laughing
Be(f)ore	honor, effort	the oar	before
Dea(f)ening	roar, disaster	dea(f)ening	deafening
Li(fe)like	picture, praise	lie-like li(fe)like	lifelike
O(ft)entimes	wander, alone	on time autumn-time	olden times on time
Stu(ff)ing	animals, taxidermy	starting	stuffing
Ba(b)ies	bachelor's, bugbears	baize	bays
Voca(b)ulary	important, book	voca(b)ulary	voca(b)ulary
Descri(b)ing	personal, adventures	descrying	describing
Scri(bb)ling	verse, genius	shrilly	squirling
No(b)ler	men, better	nola	older
Ro(bb)ing	genteel, vocation	drawing	calling
Ru(b)ies	diamonds, precious	Ruiz	Ruiz
Scru(bb)ing	floor, artistic	scrawling	scru(bb)ing
Ca(p)able	better, things	ca-able	capable
Ra(p)acious	politicians, monopolized	veracious	veracious
Re(p)entance	itself, constructive	prentice, pre-empted	the entrance
She(ph)erds	flocks, night	charades	charade
Gri(pp)ing	man, throat	spearing	grinning
Slo(p)ing	walls, ascent	flowing	flowing
Dro(pp)ing	wall, escape	drawing	drawing
Stu(p)endous	gorge, wonder	stu(p)endous	stu(p)endous
Cu(p)id	life, part	Hewet	stupid
A(n)omalous	position, comment	anomalous	anomalous
Ge(n)eral	disaster, panic	Jerrold	Jerrold
A(n)yone	done, better	a-one	A-1
Pho(n)ographs	products, decade	phonographs	phonographs
Ho(n)or	before, effort	all	awe
Croo(n)ing	scandalous, tales	accruing	accruing
Combi(n)ations	capital, dangerous	combinations	combinations
Su(pp)osing	true, result	supposing	supposing
Fortu(n)ately	well, armed	fortunately	fortunately
Fu(nn)els	clouds, smoke	false	funnels
Cra(z)y	stories, believed	cra(z)y	crazy
Re(s)ults	whatever, interesting	real	real
He(s)itation	critical, failure	citation	hesitation
Civi(l)ized	nations, war	civilized	civilized
Ro(s)es	violets, grown	rose	rose
U(s)ing	gun, club	hewing	hewing

In all, 358 judgments were recorded; 183 with context and 175 without context. Table II shows the percentage of correct perception for both classes.

TABLE II.

	Without Context.	With Context.
Total Judgments,	175	183
Right Judgments,	50	96
Wrong Judgments,	125	87
Per cent. Right,	28.5	52.4

Lest the 28.5% of this last determination may be thought inconsistent with the 42.0% of Table I, it will be well to explain that the words chosen for the test represent only those members of the B-series which were the most difficult to perceive after mutilation. The following conclusions seem warranted:

2. *When mutilated words are given with a minimum of context, the chances for their correct perception are increased by 82% as compared with their chances of correct perception when given without context.*

3. *The fact of mutilation is readily noticed in the single words given without context, even though the word be finally correctly perceived; the elision is not so readily noted when the word is given with a minimum of context.*

These conclusions are again in full agreement with Pillsbury's results for the visual word.[1]

(c) *Words given at or near the Beginning of Complete Sentences.*

Two of the sentence series—A and B—furnished the data for this determination. Tables III and IV give the results.

TABLE III. SERIES AA.

	Given Alone.	At the Begining of Sentence.
Total Judgments,	260	390
Right Cases,	9	288
Wrong Cases,	251	102
Per cent. Right,	3.5	73.8

Here the A-words have leaped, by the influence of context, from 3.5% of correct perceptions, when given alone, to 73.8% of correct perceptions, when placed at the beginning of a complete sentence. The B-words have increased much less rapidly, as the following Table shows.

[1] Pillsbury: *op. cit.*, p. 361.

TABLE IV. BA SERIES.

	Given Alone.	At the Beginning of Sentence.
Total Judgments,	450	944
Right Judgments,	189	557
Wrong Judgments,	261	387
Per cent. Right,	42	59

The following conclusions are to be drawn:

4. *Polysyllabic words when mutilated are more easily recognized than monosyllabic words under the same conditions, but, when given in context, are not helped by the context as much as are the monosyllabic words.*

5. *When mutilated words are placed at or near the beginning of complete sentences, the chances for their correct perception are increased remarkably, the amount of increase varying with the character of the word, being greater for monosyllables and less for polysyllables.*

(d) *Words placed in the Middle of Sentences.*

Only one of the sentence-series—Cb—was used in this determination. The C-words were all monosyllables; hence, the results of this determination are comparable with the Aa series of Determination 'c.' Table V gives the results.

TABLE V. THE CB SERIES.

	Word Given Alone.	Given in Middle of Sentence.
Total Judgments,	260	498
Right Judgments,	34	399
Wrong Judgments,	226	99
Per cent. Right,	13.0	80.1

Here we find a distinct gain in correct perception over the last determination. In comparing this series with series Aa of Determination 'c,' the objection may be raised that the C series has already been proven more easily perceived than the A series, and that, therefore, the gain from 73.8% (the result of the Aa series of Determination 'c') loses its significance. When, however, we take into account the long leap that both series make when given the advantage of context, this difficulty does not appear so great as at first sight. The following conclusions seem to be justified:

6. *When mutilated words are placed in the middle of complete sentences, there is a slight but significant increase in the percentage of correct perceptions as compared with the perceptions of the similar words placed at the beginning of complete sentences.*

7. *When mutilated words are placed in the middle of complete sentences, they are much more amenable to correct interpretation than when given without context.*

(e) *Words given at the End of Complete Sentences.*

Series Ac, Bc, and Cc are represented in this determination. The results are shown in Tables VI, VII and VIII.

TABLE VI. THE AC SERIES.

	Given Alone.	Beginning of Sentence.	End of Sentence.
Total Judgments,	260	390	114
Right Judgments,	9	288	100
Wrong Judgments,	251	102	14
Per cent. Right,	3.5	73.8	87.7

TABLE VII. THE BC SERIES.

	Given Alone.	Beginning of Sentence.	End of Sentence.
Total Judgments,	450	944	507
Right Judgments,	189	556	408
Wrong Judgments,	261	387	99
Per cent. Right,	42	59	80.4

TABLE VIII. THE CC SERIES.

	Given Alone.	Middle of Sentence.	End of Sentence.
Total Judgments,	260	498	404
Right Judgments,	34	399	366
Wrong Judgments,	226	99	38
Per cent. Right,	13.0	80.1	90.5

The conclusion follows:

8. *The position most favorable for the correct perception of a mutilated word is at the close of a complete sentence.*

Table VII shows the general relations of all the classes.

TABLE VIII. GENERAL RELATIONS.

Min. Con.=Minimum Context. T=Total Judgments. R=Right Judgments.

Class.	Alone.		Min. Con.		'a'		'b'		'c'	
	T	R	T	R	T	R	T	R	T	R
A	260	9			390	288			114	100
B	450	189	183	96	944	556			507	408
C	260	34					498	399	404	366
	970	232	183	96	1334	844	498	399	1025	874
P. c'nt. R't,	23.9		52.4		63.2		80.1		85.2	

9. *The temporal position of a mutilated word in the succession of contextual elements with which it is given, determines the amount of injury which the word as an unit of auditory perception sustains through mutilation.*

PROBLEM II. THE RELATIONS OF THE SYMBOLIC ELEMENTS TO ONE ANOTHER IN AUDITORY PERCEPTION.

Have the various consonants, or classes of consonants, varying degrees of significance for perception? Are there among the auditory symbol elements certain elements which are 'determining' and certain others which are 'indifferent,' as Goldscheider and Mueller maintain to be the case in visual symbol elements? We have already found that the *position* of an element is a determining factor in perception. This, however, can be interpreted as analogous to the influence of context; for since the initial element possesses the greatest significance for perception, it is reasonable to suppose that the mid and final elements lose significance through the associative supplementing of the preceding elements. The question now arises: apart from this associative supplementing, are there other objective or physiological factors which give the various elements a varying degree of significance? Are certain consonants, either because of the ease with which they are produced or by reason of their peculiar quality, more fundamental than other consonants?

The word-series B was used in this experiment, the general object being to determine what consonants could be elided with the least injury to the perception of the word. Table IX gives the results. The percentages represent all the judgments made upon the mutilated words, whether with or without context, the assumption being that the context helped all classes of consonants impartially.

TABLE IX.

Injury Worked to Perception of Mutilated Word by Elision of Different Kinds of Consonants.

CONSONANT ELIDED.	TOTAL JUDGMENTS.	RIGHT.	WRONG.	
Mutes.				
p	47	20	27	
b	28	9	19	
d	44	25	19	
t	43	22	21	
g	26	12	14	
k	40	14	26	
Totals,	228	102	126	44.7% Right.
Spirants.				
f	23	9	14	
v	38	18	20	
th	27	11	16	
j	43	25	18	
ch	29	13	16	
Totals,	160	76	84	47.5% Right.

Sibilants.				
s	36	20	16	
z	16	3	13	
sh	42	21	21	
zh	18	11	7	
Totals,	112	55	57	49.1% Right.
Nasals.				
m	43	17	26	
n	32	23	9	
ng	9	2	7	
Totals,	84	42	42	50.0% Right.
Semi-vowels.				
w	10	7	3	
r	36	28	8	
l	42	28	14	
Totals,	88	63	25	71.6% Right.

10. *The elision of mutes works the greatest injury to the perception of a mutilated word; the elision of the semi-vowels works the least injury to such perception. Elision of spirants, sibilants and nasals works greater injury than the elision of semi-vowels, and less injury than the elision of mutes.*

We have in this instance a striking correlation with the facts of language development. In the phylogeny[1] and ontogeny[2] of speech the mutes are the first consonants to appear. They are also the easiest to form, involving the least complex musculature and the slightest delicacy of co-ordination.

11. *The consonants which are of the greatest significance in the auditory perception of words are those which involve in their production only the coarser articulatory combinations. They may, therefore, be considered as the more fundamental elements of auditory symbolism.*

These results may now be compared with the substitutions which the various observers made when the words were misperceived. The data of this determination are mostly such words as were *not* filled out by the observer into 'meaningful' but into nonsense symbol-complexes. Hence the substitutions made may well be considered as, in the main, those which followed the 'line of least resistance;' those, in other words, which required the least expenditure of energy for their production. Some examples are given below:

Word Given.	Word Reported.
sla(mm)ing	slatting
no(m)ination	notination

[1] Cf. Whitney: Life and Growth of Language, p. 68.
[2] Cf. Tracy: Psychology of Childhood, p. 127.

Word Given.	Word Reported.
fe(tch)ing	fetting
ga(th)ering	ackering
na(ti)on's	valiance
a(g)ony	arry
pu(g)ilist	purellas
du(ck)ing	dunning
mo(m)ent	oak cent
ca(v)il	cattle

TABLE X.

The Comparison of Multiple and Single Elements Appearing in the Substitutions.

	No. of Elements Represented.	No. of Substitutions.	Average for each Element
Single Elements,	22	221	10.
Multiple "	14	21	1.5

By 'multiple elements' are meant combinations of single consonants or digraphs.

12. ***Multiple elements are substituted much less frequently than single elements; in the proportion of 15 to 95, or, approximately, 1:6.***

TABLE XI.

The Comparison of Different Classes of Single Elements Appearing in the Substitutions.

Total Number of Substitutions...............221

Mutes.		Spirants.		Sibilants.		Nasals.		Semi-vowels.	
p	3	f	1	s	6	m	2	v	63
b	6	v	7	z	1	n	2	r	26
d	11	th	5	sh	4	ng	8	l	21
t.	26	j	3	zh	0			' y	15
g	1	ch	2						
k	8								
Total,	55		18		11		12		125
Av. for each Mute,	9.1	Spiran ,	3.6	Sibilants,	2.7	Nasals,	4	Semi-v'ls,	31.2

The preponderance of semi-vowels substituted may seem remarkable in the light of the last determination, where we pointed out that the mutes are not only the 'easiest' elements to produce vocally, but also the most fundamental in the genesis of speech, while the semi-vowels are the hardest to acquire and the latest to develop, both phylogenetically and ontogenetically. But while they are the latest to develop, they are not, once mastered, the most difficult to use, but rather are among the easiest. In the practiced use of language, "each class (vowels and consonants) draws the other toward itself; the vowels become more consonantal, the consonants become more vocalic."[1] Hence, it might well be expected that the semi-vowels, standing as they do on the border line

[1] Whitney: Life and Growth of Language, p. 69.

between the voiced and the unvoiced elements, should appear most frequently in the substitutions of adult speakers. In view of this fact, the following conclusion seems to be justified:

13. *When different single elements are substituted for the elided elements in mutilated words, the semi-vowels are chosen most frequently, the proportion being approximately three semi-vowels to two substitutions from all other classes. When semi-vowels are not substituted, the mutes are chosen more frequently than either the sibilants or the nasals, in the proportion approximately of three mutes to one substitution from any one of the other classes except semi-vowels.*

B. THE CONSCIOUS PROCESS INVOLVED IN THE APPERCEPTION OF SPOKEN SYMBOLS.

§ 1. *Object.*

From the series of mutilated words that were given, now singly, now with a minimum of context, now at the beginning, now in the middle, and now at the end of a complete sentence, it is evident that the 'setting' of a word is the determining factor in its apperception. The problem that confronts us, therefore, is this: Given a complex of sounds, otherwise perceived simply as such a complex, what are the conscious processes by which this complex acquires 'meaning;' by which it is not merely perceived as sound, but apperceived as a 'meaningful' symbol?

Apperception is used in this connection to denote the reaction of experience upon new contents, or, as Pillsbury puts it, "apperception represents the influence of general experience in consciousness."[1]

This connotation of the term apperception, now generally adopted, was vaguely suggested by Leibniz;[2] but it was the Herbartians who first gave it an important significance in psychological nomenclature. According to Herbart,[3] a new idea is apperceived by an older idea or by a complex of older ideas. With Drobisch,[4] the apperceiving idea becomes a distinct 'psychological subject.' There is a psychological subject corresponding to every characteristic attitude of the mind. Now we are teachers, now students, now members of a political community. In every case a special psychological subject presides over the mental life, and the nature and constitution of this subject determine the form in which the newly entering contents shall be received. Waitz[5] introduces the doctrine of apperception by 'coenæsthesis.'

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[1] Pillsbury: *op. cit.*, p. 388.

[2] Leibniz: Philosophical Works (Tr. Duncan). New Haven, 1890, pp. 219.

[3] Herbart, J. F.: Psychologie als Wissenschaft. Sämmtliche Werke (Kehrbach's ed.), Langensalza, 1892. Bd. VI, pp. 140 ff.

[4] Drobisch, M.: Empirische Psychologie nach wissenschaftlicher Methode. Leipzig, 1842, p. 135.

[5] Waitz, T.: Grundlegung der Psychologie. See also Stout, *Mind*, Vol. XIV (1889), p. 366.

Coenæsthesis is the mental attitude, the 'common feeling,' which is produced by every form of stimulus. In other words, coenæsthesis is the resultant of experience. With Lazarus,[1] an apperception is joined to a perception in the act of assimilation. The apperception is thus conceived as a structural pattern of the mind. It is, however, an active agent, and its efficiency is due to the working-over which it has undergone throughout the course of experience. Steinthal[2] means by apperception all the psychical factors and activities which mediate a cognition. It is the movement of two ideas governed by the *Weltanschauung* of the subject,—the movement of two ideas for the production of a cognition. Stout[3] includes under apperception such processes as understanding, interpreting, identifying, subsuming, etc. In all these processes, a presentation "acquires a certain significance for thought by connecting itself with some mental preformation as this has been organized in the course of previous experience." The process of apperception coincides substantially with that of attention. In the Herbartians, both the agents and the materials of apperception are ideas or idea complexes; in Stout, the materials of apperception are involved in the concept of mental 'systems.' A mental group or system is a systematized tendency, and the union of such groups or systems is the confluence of different modes of mental activity. (*Cf.* the 'psychological subject' of Drobisch.) Regarding the agent of apperception, Stout renounces the Herbartian concept of ideational activity, and considers apperception as a conative process. With Wundt,[4] apperception is the process through which one idea becomes clear and distinct, while others remain vague and indefinite, the entire process being accompanied by a feeling of activity, by the inhibition of irrelevant ideas, and by other accessory phenomena.

The problems in a study of apperception are revealed more clearly if the dichotomy between a structural and a functional psychology, as proposed by Professor Titchener,[5] is rigidly made and adhered to. Apperception is a *function* of the mind. It has its *structural* pattern, *i. e.*, there is a certain mental state or condition which the apperceiving consciousness uniformly takes, and this state or condition is called attention.[6] In a study of apperception, then, we have to inquire, what structural elements or compounds of elements carry the function of apperception. In what proportions are sensational and affective elements present, under different conditions, in the apperceptive consciousness? The mind assimilates the new material which is presented to it in a form determined by the environment.

[1] Lazarus, M.: Das Leben der Seele. Berlin, 1878, pp. 251 ff.

[2] Steinthal, H.: Einleitung in die Psychologie, etc. Berlin, 1881, pp. 166-263.

[3] Stout, G. F.: Analytic Psychology. London, 1806. Vol. II, pp. 110 ff.

[4] Wundt, W.: Grundzüge der physiologischen Psychologie. Leipzig, 1893. Bd. II, pp. 274 ff.

[5] Titchener, E. B.: An Outline of Psychology. New York, 1899, pp. 21 ff. The Postulates of a Structural Psychology, *Philosophical Review*, Vol. VII, 5. (Sept., 1898.)

[6] *Cf.* Kuelpe, O.: Outlines of Psychology (Tr. Titchener). London, 1895, pp. 423 ff.

What are the conscious processes which, on the structural side, constitute this assimilation? What is it that determines the particular pattern of the given apperceptive consciousness? Why are such and such perceptions and ideas in the focus, and such and such perceptions and ideas in the fringe of consciousness? What is the nature, under the given conditions, of the elements which fall in the focus, and what is the nature, under the same conditions, of the elements which fall in the fringe? Is there any uniformity with which these several arrangements of mental 'stuff' occur? If there is, does it suggest, directly or indirectly, a general postulate upon which a psychology of function can build?

Viewing our own problem—the apperception of spoken symbols—from this standpoint, we have to ask: What is the character of the associative and recognitory processes that underlie the apperception of symbols? In terms of what sense-modalities are our symbols interpreted? What part do mood, affective tone, environment, past experience, and similar factors play in the interpretation?

§ 2. *Method.*

The method employed in this determination was that of introspective analysis. The sentences were the same as those used in the first two determinations; a sample series has been given above (p. 88). The procedure was, in brief, as follows. After the sentences had been reproduced by the phonograph and repeated by the observer, the latter was instructed: (1) to give an introspective account of the manner in which he came to fill out the mutilated word, providing that the mutilation was recognized; and (2) to add all possible information as to the character of the mental processes which went on during the apperception of the sentence, with especial regard to the pattern of the apperceptive consciousness,—the presence or absence of definite and tangible 'imagery,' the concomitant affective phenomena, kinaesthetic sensations, etc. The results of the experiment fall into two sections, corresponding to these two divisions he problem.

3. *Observers.*

ie value of the introspective reports must depend in large ure upon the training and ability of the various observers. ie four observers whose protocols embody such reports, were professional psychologists of from four to six years' ical training and experience. The fourth was a student of years' training in psychological method. All were very alive to the value of accurate introspection, and could rentiate clearly between the psychological and the logical ations of the matter with which they dealt.

following observers offered their services for this deter-

mination: Miss F. M. Winger (*W*), Fellow in Psychology; Miss J. A. Cochran (*C*), senior student in psychology; Dr. G. M. Whipple (*Wh*), Assistant in Psychology; and Dr. W. B. Lane (*L*), Honorary Fellow in Psychology,—all of Cornell University. *W* and *L* are predominantly visual in type; *C* is predominantly auditory; and *Wh* auditory-visual.

The experimental work began in October, 1899, and continued until June, 1900. The experimental hours were ten, eleven and twelve in the morning. No tests were taken in the afternoons. *Wh* gave one hour a week to the work, *L* and *C* two hours a week, and *W* three hours a week.

§ 4. *Results.*

(a) *The Interpretation of Mutilated Symbols: The Principle of Contextual Supplementing.*

We have seen that, when a mutilated word is given alone, the chances are that its meaning will be lost upon the hearer; but when it is given in context, the chances are that the elisions will be filled out and the word supplied in its correct form. When a word is spoken erroneously, but is correctly perceived by the hearer, the process by which the errors are filled out has been described as 'associative supplementing.'[1] It is obvious that this involves a certain form of apperception. The erroneous part of the spoken word is filled out immediately from the hearer's experience, and this is always an instance of simultaneous association. But when the word is recognized as mutilated, the correct form is provided in large part by the context, and is only at first suggested and later confirmed by the mutilated form. This process may be called 'contextual supplementing,' and is an instance, not of simultaneous, but of successive association.[2] The greater part of the elisions in our sentences were supplied in this way.

14. *The mutilated word given in context is not, as a rule, filled out at once by associative supplementing, but is changed into its correct form by a process of successive association which, inasmuch as it is dependent almost entirely upon the context, may be called contextual supplementing.*

Illustrations: "He sold his ho(me) for a mess of pottage." *Wh* first misinterpreted *ho(me)* as *hole*. He then "tried to think what Esau sold;" *birthright* came up by successive association, then *home* was readily supplied.

"The matter is a function of ti(me) and space." *L* misinterpreted *ti(me)* as *tide*, but the juxtaposition of *space* led to the substitution of *time*.

"Is it the man or the no(se) in Cyrano?" *C* supplied *nose* after *Cyrano* had been spelled for her.

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[1] Titchener: *op. cit.*, pp. 216 ff. See also Bawden, A Study of Lapses. pp. 41-44.

[2] Titchener: *op. cit.*, p. 216.

References which change gradually as the context proceeds,	40 instances.
References which take a figurative meaning in its literal sense,	5 "
Contexts erroneously perceived and curiously interpreted,	96 "
References inconsistent with the context,	9 "
Total indefinite, changing and obscure references,	168
References indistinct or absent:	
Reference vague and unorganized,	48 "
Only the auditory experience of the sentence in consciousness,	16 "
Familiarity with the sentence precludes definite and distinct reference,	6 "
Peculiarity in the mechanism of the sentence makes the reference indistinct,	5 "
Indistinct reference coming very late,	9 "
Total indistinct or absent references,	84 "

15. *Under the conditions of our experiment, and with the observers tested, the apperception of auditory symbols involves the presence in consciousness of visual and verbal ideas mainly; i. e., the conscious 'stuff' of the auditory symbolic apperception is made up in large part of visual and verbal (visual-auditory-kinaesthetic) sense elements. The auditory and kinaesthetic elements (apart from the rôle which they play in the formation of the verbal idea)*[1] *seemingly form but a small part, and the temperature, taste, and smell elements a still smaller part, of this 'stuff.'*

16. *The most complete form which the visual sense elements take is that of an ideal reproduction, more or less faithful, of a typical environment as represented by the context. Such a reproduction is common only with visually-minded observers and under optimal conditions of attention. It is usually complicated with other sensible and affective elements, but in such cases the visual elements predominate and occupy the focus of attention.*

Illustrations: "Not a man ha[s][2] had his vote refused him." *L* visualized a voting card and a polling station. The vote was upon the 'license' question. The consciousness of this last reference took the form of the word 'temperance' printed with a capital T. There was some excitement about the city which, in the ideal reproduction, took the form of noise memories. *Wh*, on hearing the same sentence, visualized the interior of the town hall of his native city, where voting was going on.

"The dogs were held in lea[sh]." *L* pictured a hunt, with a number of horses, dogs, etc., in the foreground.

"The principal plants indigenous to America are the potato, tobacco

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[1] *Cf.* Titchener: *op cit.*, p. 208; Bawden: *op cit.*, pp. 59-60; Raymond Dodge: Die motorischen Wortvorstellungen, pp. 2-3.

[2] A letter enclosed in brackets [ ] or parentheses ( ) is the elided letter of the sentence. Where the brackets are used the elision did not involve the misinterpretation of the word.

and mai[ze]." *W* visualized maize and potatoes growing and tobacco manufactured.

"The ship could be traced by the smoke from her fu(nn)els." *W* misinterpreted *fu(nn)els* as *bows*. She reported the following situation: "The ship was on fire. I was on another ship at first, and could see the smoke coming over the horizon. Then I was on the burning ship watching the smoke coming from the bows."

"The safe door closed with a sna[p], and the cashier was a helpless prisoner." With this sentence *Wh* had a "vague visualization of a man standing in the middle of a bank office. The safe door was back of him. He was a tall man with a smooth face and a derby hat. He had a valise in his hand and appeared to be startled at something. He was the cashier." In this case, as in many others which we shall cite later, the reference was not in every way consistent with the context. *Wh* remarked upon this inconsistency in the protocol.

"A balmy bree[ze] wafted us to the south." *C*'s reference was not immediate, but followed some seconds after she had repeated the sentence. She visualized a river between two banks. "The river seemed very long."

"Gree[d]ily he seized and ate the food." *Wh* visualized a man eating with both hands.

"By goa[d]ing the oxen constantly, he managed to move slowly on." After the sentence had been repeated, *Wh* referred it to a country road near Topsfield, Mass. He visualized a yoke of oxen and a driver. *W*, with the same sentence, visualized an ox-cart and a man walking beside the oxen.

"The peti(ti)on received some attention." *L* misinterpreted *peti(ti)on* as *Acteon*, which he took to be a Greek name. The sentence referred to a man's reception—a public reception to a famous man—which *L* visualized, together with a Greek audience which was applauding.

"He sleeps in a nameless gra[ve]." *Wh* visualized a soldier's grave on the side of a hill against a background of pines.

"The seed was covered with a white fu(zz)." *L* interpreted this sentence as, "The seed was covered with a white fog." He later supplied *sea* for *seed*, and with this he visualized the sea enveloped in fog and a steamer moving through it. The ideas *slow-speed* and *fog-signal* (modalities uncertain) were also present.

"The sermon was unconscionably lo[ng]." *W* visualized a "lot of people sitting and waiting for the end to come. It was very quiet." She did not see the preacher.

"Ships were frequently wrecked upon the ree[f]." *L* visualized the open sea off the Manacles, and in it a ship partially submerged. This was supplemented by the verbal associate 'Paris.'

"Schools of fish are found off the ba[r]." *C* visualized a stretch of sand, the yellowness being especially noticeable.

"(Sh)ot and shell were poured into the fort." *L* interpreted this as "Bombs and shell." He referred it visually to the naval manœuvers off Santiago. He visualized a "definite circular arrangement of ships in motion." A schematized parabolic curve of a projectile, and a mass of white smoke were also imaged visually.

"[C]aves of great extent honeycomb the hills." *Wh* visualized the side of a hill pitted with small holes.

"[K]een business men perceived the opportunity." *Wh* associated this successively to the name of a leading business man of his native town (auditory-verbal) and visualized the square of business houses in this town.

"That splendid ru[g] came from the Orient." *L* visualized a map of the eastern Mediterranean, the Archipelago being represented with great detail. Orient was visualized with a capital O. There was a fleeting image of a typical Turk, supplemented by the verbal idea, 'Ottoman.'

"The howling wind set the windows rattling and the doors sla[mm]ing." *W* heard the slamming and the rattling. "The curtains at the window were green." (This last bit of introspection shows how irrelevant are some of the details that come into the focus of attention and occupy a position in consciousness which is quite inconsistent with their significance to the 'meaning' of the sentence.)

"I had often witnessed the scene he had been descri(b)ing." *L* interpreted *descri(b)ing* as *descrying*. The conscious contents had reference to an outlook from a ship's deck,—looking at a distant object through binoculars. *L* also visualized a number of persons "shielding the eyes with the hand;" also the water and a bulwark. With it all he noticed a strain about the eyes,—a 'squint.'

"We were to travel through Europe on bi[c]ycles." *W* referred this visually to a woman of her acquaintance who expects to visit Europe in this way. She saw her climbing a hill on her wheel. "The day was bright and clear."

"On the wall hung a painting and two e(tch)ings." *W* referred this to two long high walls with the pictures upon them. *L* misinterpreted the sentence as, "On the wall hung a picture at two angles." He visualized an unframed screen with a painting upon it. This was standing in the corner and bent to the angle of the corner. "The picture was very large."

"He went into business with his fa[th]er." *L* referred this verbally to a plumber and visualized a dirty-faced, lead-marked man dressed in working cottonades.

"Crou(ch)ing by his side was the faithful dog." *Wh* interpreted *crouching* as *following*, and visualized a man and a dog. "The dog was large; the man poor and shabby. The dog was 'sneaking' along with his head down."

"The roof was supported by an iron bea(m)." *L* misinterpreted *bea(m)* as *prop*. He visualized a building supported from the side by a long pole or buttress. There was a detailed image of a long parallel epipedal iron support. This was supplemented by the idea (modality uncertain) of a wind-storm threatening the building.

17. *The form which the visual reference most commonly takes is that of an ideal reproduction, not of the contextually represented environment as a whole, but only of certain parts of such an environment; the visual idea merely serving to reinforce the general conscious contents which accompany the apperceptive process, and not necessarily forming the focal part of such contents.*

Illustrations: "(Z)eal is not lacking for the enterprise." This was interpreted by *L* as "Steel is not lacking for the enterprise." While the sentence meant to him that "backbone and force were not lacking," he supplemented this interpretation with the visual image of a bayonet.

"[R]eed instruments are replaced by string instruments." *Wh* in this connection visualized an orchestra. The reed instruments were represented by clarionets, the string instruments by violins. These things were reproduced very vaguely. With the same sentence *L* visualized a mouth 'harmonica' and a banjo; *i. e.*, the generic names reed and string were reduced to these concrete objects.

"The army comprised some ten thousand (m)en." *L* misinterpreted *(m)en* as *ants* and later as *tents*. With *ants* the reference was to the militarism of an ant colony. *Tents* gave rise to the visual reproduction of a militia camping ground covered with white tents. "The latter was a definite picture, the former only a word and the image of an ant."

"Con(s)ider for a moment the effects of the measure." This was reported by *L* as, "It bettered for a moment the effects of the measure." *L* visualized a "lot of heads and one man standing up," which represented for him the idea of a legislative assembly.

"We detected a faint odor of [m]usk." *L* imaged a wet muskrat, the long tail being especially distinct.

"The dim[l]y lighted chapel was filled with women." *C* referred this visually to Sage Chapel, Cornell University. *W* referred it to the chapel of a Chicago hospital. *L* referred it to the interior of Sage Chapel.

"The un[m]apped territory of the earth is not extensive." *L* "thought in a general way" of government surveys and visualized two men who are engaged upon the coast survey.

"Ingen[io]us contrivances sometimes earn fortunes." *W* referred this to a new piece of acoustic apparatus in the psychological laboratory. Then, by way of the fall-phonometer which stood near by, the idea of 'slot-machine' was successively associated.

"To touch the he[m] of his garment would cure all diseases." *Wh* imaged a Sunday School chart. *C* visualized a garment with a wide hem.

"The time was ri[pe] for a concerted movement." *L* referred this to Roberts's campaign in South Africa. This reference was partly verbal and partly visual. He pictured Roberts and the outline of a besieged city. The rest was supplemented verbally except for an indefinite mass of soldiery.

"By his si[de] crouched the faithful dog." *W* "saw the dog—a yellowish brown bird dog. He had been mistreated and was cringing." *Wh* visualized a man "and a thin, scrawny dog with its tail between its legs. It was a winter scene."

"Several black ba(ss) were caught in the stream." *L* misinterpreted *ba(ss)* as *bear*. He visualized a black bear and a deer swimming in a stream. The prominent idea in consciousness, however, was connected with the laws forbidding the killing of deer during certain seasons.

"It is often hard to reduce a compound to its ele[m]ents." The verbal reference 'chemical analysis' was probably the prominent part of *L*'s apperceptive consciousness. It was supplemented by a vague visualization of a number of test-tubes.

word was not in the voca[b]ulary." *L* referred this to a word
r's 'Elemente der Psychophysik.' He could not remember
but visualized a page and knew its position on the page.
he same sentence visualized Webster's Dictionary.

g was set with ru[b]ies." *L* pictured a ring with a beau-
g. This was accompanied by the verbal associate 'mar-
thought particularly of the coloring of the stone and
f it was explainable on the same principle as the coloring
This involved the visual reproduction of a diagram of
enomena.

oubts the moral efficiency of re[p]entance." Here the
uction of the gates of the Auburn prison was an accessory
erceptive consciousness.

d a roo[m] on the fourth floor." *L* referred this to a

building on the university campus. He visualized the building. *C* visualized the same building. *Wh* imaged a dormitory at Brown University. None appears to have had a definite visual reference to the man or to the room, the building monopolizing the visual consciousness of the time.

"O[v]er the divide was the promised land." *W* thought of *divide* visually as a chasm or gulch. With *L*, *divide* suggested a log-boom in a river. *Promised land* gave rise to the reproduction of picture of Moses on Nebo, which *L* had seen in Sunday School.

"A dea[f]ening roar heralded the disaster." *Wh* visualized an explosion, but heard nothing. With *L*, *roar* suggested a waterfall in visual terms and the sound of a waterfall in auditory terms.

In all the above examples it will be noted that the visual part of the apperceptive consciousness is frequently supplemented by other references, principally verbal in character, all of which function together in apperception. Now this group of conscious elements comes into prominence, now that group, and only the more striking are noted in the introspective reports. As *L* said at the close of one report: "The interpretation involves fragmentary images, now of this, now of that modality. I can note only a few of these, but there are others there." As to the importance of the kinaesthetic elements upon which Bawden[1] has laid so much stress, the results of our experiments permit only of the assertion that the kinaesthetic factors very seldom come into the focus of consciousness. Some of the more typical references of this class are given below:

"(Kn)eel before misfortune if you will." *Wh* misinterpreted *(kn)eel* as *yield*. The kinaesthetic concomitants of kneeling and bowing were present.

"[H]unt for the word in the dictionary." *L* experienced the 'feel' of rapidly 'leafing' the pages of the lexicon in hunting for Greek words. He also visualized the face of a man in the library of the University of Toronto,—'a big fellow with a blue coat.'

"[Sh]un evil companions." Here *L*, along with a verbal and visual reference to a Sunday School, experienced an auditory-kinaesthetic reproduction of a Sunday School song.

"[J]oy and sorrow are sprinkled about equally among men." *Wh* "interpreted *sprinkled* by a centrally-excited arm-movement idea of scattering seed."

"Har[m]onious relations have been established." *Wh* reported in the protocol: "'Harmonious relations' means a smoothing over; this in my consciousness is the image of an outward movement of the hands."

"The care of the tee[th] is a matter of importance." *Wh* experienced the kinæsthetic concomitants of brushing the teeth.

"He was not su[re] of the matter." *L* visualized a person perplexed; *i. e.*, with certain characteristics of the face denoting perplexity, such as the drawing together of the eyes and a general tension. *L* reproduced such an adjustment.

"One often feels the nee[d] of exercise." *Wh* referred this to the idea of bicycling. In this idea the kinaesthetic elements were predominant, but they were supplemented by verbal and visual elements.

[1] Bawden: *op. cit.*, pp. 65 ff.

He imaged himself as coming up a sharp incline near the university library. Just before hearing the sentence he had been conversing about bicycling.

"Every man possesses an ele[m]ent of the divine." In this connection *Wh* experienced a kinaesthetic 'upness' supplemented by a vague visualization of clouds and the verbal idea, 'God.'

"He was unable to maintain his po[s]ition." *L* referred this to the situation a public lecturer would be in if his position was assailed. This reference took form in "internal disturbances, such as quailing."

"Gri(p)ing pains preceded death." *L* misinterpreted *gri(p)ing* as *lying*. He had a verbal and kinaesthetic reference to a death struggle. This involved centrally excited muscle and strain sensations.

"Bo(wl)ing is an excellent exercise." *L* misinterpreted *bo(wl)ing* as *rowing*. He referred the sentence to an experience in camping, the prominent part of the recollection being the 'feeling' of a well muscled arm.

"He was wrapped in the soundest slee[p]." *L* visualized a man wrapped in a blanket, and referred the sentence to the idea of calmness and rest in terms of muscular relaxation.

"It is said that there is always roo[m] at the top." Here again *Wh* experienced the kinaesthetic idea of 'upness.'

"As a joke it was simply hu[ge]." *Wh* noted a "motor laughter fringe" as a prominent part of the apperceptive consciousness.

Purely auditory supplements are met with in the reports much more infrequently than kinaesthetic supplements, and it may be inferred that they very seldom come into the focus of attention during the apperceptive process. A few examples are given below:

"He had been shot through the chest, and lay on the ground wri[th]ing." *L* referred this to a wounded soldier; he "seemed to hear him groan."

"They were almost stunned by the concu[ssi]on." *L* imaged the sound of blasting, and accompanied this with a motor adjustment about the face.

"The concussion was dea[f]ening." Here *W* experienced a "peculiar sensation in the ears."

"The man betrayed his Sco[tch] blood by his accent." *L* imaged a large, freckled-faced Scotchman; "seemed to hear a Scotch 'twang.'"

In the sentences already cited, "Not a man ha[s] had his vote refused him," and "A dea[f]ening roar heralded the disaster," *L* reported auditory references, in the first case to the noise of a city on election night, and in the second case to the roar of a waterfall.

Taste and smell elements may be said to play a very unimportant part in the ordinary apperceptive consciousness. The following sentences gave the only instances of such references.

"Diseased [illegible] are studied by pa[th]ologists." *W* referred this to the idea [illegible] logical laboratory. This was mainly visual but was supplem[illegible] a centrally-excited olfactory sensation.

"Th[illegible] smo[th]ered." *L* visualized a dense black [illegible] a stifling 'feeling' in his throat and nose, [illegible] lly the odor of smoke.

[illegible] faint odor of [m]usk." *L* ideally reproduced a [illegible] musk odor.

[illegible] lly liked by the small boy." *Wh* misinterpreted

(*j*)*am* as *ham* and ideally reproduced a faint taste of ham. (This was just before the lunch hour.)

Temperature elements were noted in only two instances:

"The winter came and the river fro[ze]." *W* had a faint ideal reproduction of a sensation of cold.

"The howling of the wolves disturbed our slee[p]." *L* visualized a mountain side covered with snow. This idea was supplemented by temperature images.

18. *Verbal ideas exist more frequently as associative or contextual supplements than as the focal objects of the apperceptive consciousness.*

Illustrations: "[D]eeds of kindness are seldom appreciated." *L* visualized a person of his acquaintance who proved himself ungrateful for a service rendered him. This was verbally supplemented by 'ingratitude.'

"The navy consisted of two ships and a bri[g]." *C* was unable to remember the distinguishing characteristics of a brig. She visualized a Norwegian barge of ancient type and verbally supplemented the date '418.'

"The siege was interrupted by a tru(ce)." This was misinterpreted by *L* as "The speech was interrupted by a True." *True* meant to him the name of a man. It was associated with 'Blue,' the name of a French Canadian partisan.

"[T]ips from good authorities cause some activity in the market." Aside from a focal visual reference, *L* supplied the verbal supplements 'wheat,' 'board of trade.'

"[H]old fast to that which is good." *L* associated the names 'Paul,' 'New Testament.'

"[Sch]ools of fish were found off the bar." *L* visualized a fleet of smacks off Newfoundland in a fog. The nets were tangled and the fish could be seen through the meshes. The word *school* was taken in its educational significance and was supplemented by a vague visual idea of a schoolhouse—a large stone building.

"(J)ute is a product of the tropics." (*J*)*ute* was misinterpreted by *L* as *Juch*. This word was referred visually to a picture of Emma Juch, the opera singer, and was verbally supplemented by the words, 'Toronto Opera House.'

"The pur[p]ose of religion is ethical." *Wh* referred this verbally to 'Tarde.'

"The still[n]ess was appalling." *Wh* verbally associated the terms 'lake,' 'solitude.'

"The chan[g]es in the course were misleading." *L* visualized the catalogue of Toronto University and supplemented it verbally with the word 'curriculum.' *L* also visualized the peculiar expression on the face of an old professor who remarked that one could find nothing that one wished to find in a university catalogue. "The face was all screwed up."

"An an(ci)ent proverb is often a modern fallacy." *L* first interpreted *an*(*ci*)*ent* as *Indian*, and immediately supplemented verbally the phrase: "The only good Indian is a dead Indian." This suggested that the white man's proverbs are often fallacies, and then *ancient* suddenly came up to replace *Indian*.

"The army was sa[fe] behind its trenches." *Wh* had a vague visualization of a trench filled with men,—probably a reproduction of a newspaper sketch. This was verbally supplemented by 'Boers.'

"It was rumored that the war was o[v]er." *Wh*'s first reaction was

verbal, 'Boers.' *L* visualized a mass of soldiery and verbally supplemented 'Roberts.'

"The flocks were watched by she[ph]erds." *W* visualized a Sunday School card and verbally supplemented the phrase: "Shepherds watched their flocks by night."

"I caught the words he was dro[pp]ing." *L* referred this (in predominantly visual terms) to one person in an auditorium listening to another speaking at a long distance. This was supplemented verbally by 'heavy.'

19. *When the verbal ideas occupy the focus of consciousness, they usually take the form of antithetical or explanatory clauses. Such clauses are sometimes found as the verbal supplements of the focal idea. The sentences which lend themselves most readily to these antitheses, completions, and supplementings, are usually short sentences which arouse a minimum of visual imagery, and in which the affective element is strong; they often awaken in the hearer an attitude of dissatisfaction, a mood of humor, or a 'feeling' of incompleteness.*

Illustrations: "[P]uns are jokes of a low order." *L* immediately added, "And therefore discredited as witticisms."

"[H]eed the advice of an elderly woman." *Wb* supplemented: "Pity the sorrows of a poor old man, but heed the advice of an elderly woman."

"We did not see the train approa[ch]ing." *W*'s immediate reaction: "Were they run over?" Then came a visual reference to a kinetescope reproduction of a railroad collision. The kinetescope films were running backwards.

"His death must be reported to the au[th]orities." *L*'s verbal reaction, "Yes, death and birth registrations are compulsory."

"To slee[p]: perchance to dream: ay, there's the rub." While the phonograph was repeating the sentence, *Wb* said to himself, "He's quoting Shakespeare."

"In her arms she held the ba(be)" *L* pictured ***in her arms*** as a printed phrase. Later there came up, "In her arms she held the ***bay***." *L* could not tell how this came; he "heard *babe* very distinctly." As a matter of fact, *ba*(*be*) was mutilated and sounded *bā*. *Bā* must have been present in the fringe of consciousness, but before it came into the focus it had been associatively supplemented into *babe*. Then the original impression became focalized and *bay* was apperceived.

... scientist may claim his kinship with the a[pe]." *W*'s first ... 'A preacher must have said it."

... n broke a rib and a collar-bo[ne]." *L* visualized a rib and ... plemented the sentence with the phrase: "Pretty badly ... low? By a fall? Accident? Intentional?" "Platitude. ... l always be greater or le[ss]." *L's* reaction: ... ' Affective tone, very unpleasant.

... ionally the observer's apperceptive process anticipates ... n of symbols constituting the objective stimuli and ... spoken sentence. This phenomenon is probably often ... ause the premature apperception tallies with the com... tation; but sometimes this coincidence fails, and the ... scious of a distinct 'bias' for another form of com... s which frequently expresses itself in verbal terms.

Illustrations: "Of all that little band of men, he was the bra[v]est." *C* did not hear *band of men* distinctly, and misinterpreted it as the nonsense word, *valment*. She wished, however, to insert *regiment* and would have done so, had the sounds which she heard warranted it. The word *regiment* was consciously present as an incipient laryngeal innervation. She felt it "echo and re-echo in her throat."

"One cannot deny that most office holders are ra[p]acious." *Wh*, *C*, and *L* wished to make it *post-office* instead of *most office*. This is simply a prejudice in favor of a more familiar combination of sounds.

"The hedge needed pru[n]ing." *Wh* had already supplied *trimming* before *pruning* was perceived. He had also visualized a hedge around a small white house. This last was a boyhood recollection.

"He had left word that he would be extremely bu[s]y." Before the last words were perceived by *W*, she had already supplied "would not be at home."

"For conquest he had a strange i(tch)ing." *L* misinterpreted *i(tch)ing* as *aim*, but had a prejudice in favor of *ambition* and with this verbal idea had already supplemented a visualization of Bonaparte.

"That the man was bra(ve) no one could deny." *C* wished to say, "That the man was to blame, etc.," but she misinterpreted *man* as well as *bra(ve)*, and finally reported the sentence, "That the demand was blame, no one could deny." This was referred visually to an absconding official whose defalcation was just then the sensation of the hour.

"He desired to li[ve] in luxury while he could." *Wh* "wished to make it come out something about the 'lap of luxury.'"

"No one dared to lau(gh) at the situation." *Wh* tried to make it into: "No one dared to analyze the situation."

"Not one in te[n] knew of the transformation." *C* would rather have said *transaction*, which would have meant to her "a change in partners."

"That the movement was ra(sh) could not be denied." *Wh* visualized an army manœuvering in the field and supplemented the word 'Boers.' He had an impulse to make the mutilated word into *rare*. He "heard the two sentences pass through his mind."

"The fa(th)er who is wise may use the rod." *Wh* first interpreted *fa(th)er* as *farmer*, and expected the sentence to be," The farmer who is wise may do so and so." When *father* was supplied, the phrase, "Spare the rod and spoil the child," was supplemented.

"The co[ll]ar which he wears is number sixteen." *W* had anticipated "The collar was soiled," and had visualized a soiled collar.

21. *In the observers tested, reactions which were 'professional' in character were almost always verbal in form.*[1]

Illustrations: "The light was di[m] and faltering." *Wh* had a vague visualization,—"too faint to describe." Afterwards he thought, largely in verbal terms, of the difficulty of getting a standard illumination in experiments upon optics. *C* referred the same sentence to the construction of the laboratory dark room.

"Pleasure and pai[n] are the extremes of feeling." *L* "figured 'p-p' in print" as his note-book abbreviation for 'pleasure-pain' theor-

[1] *Cf.* Stanley, H. M.: Language and Image, *Psychological Review*, Vol. IV (1897), p. 71. *Cf.*, also, Philippe, Jean, *Revue Philosophique* Vol. XLIV (1897), p. 523: "Moins les images sont nombreuses, plus elles sont concrètes; elles se généralisent et perdent leurs caractères individuels et particuliers à mesure qu'on les renouvelle."

taneously distinct,—is in accord with Raymond Dodge's[1] results in the analysis of the verbal idea.

Illustrations: "Di[v]ersity of interest may not be a bar to friendship." *L* visualized *diversity*, *interest*, and *friendship*. The latter gave a particularly distinct *fr* at the beginning; the rest not so clear.

"The re[v]elation of the universe may be variously interpreted." *L* found flaws in *revelation* and *variously*, which led him to visualize both words as printed.

"The older animals are harder to ta[me]." *L* visualized animals, *ani* being especially distinct.

"As a Russian he was a typical Scla[v]." *L* visualized *Russian* with an especially large *R*. *Sclav* was also visualized, *v* being very clear. All this was immediate with the sound of the words.

"It was a remarkably clever tra[p]." *L* visualized *ark* of *remarkably*.

"He seemed to te[ll] the truth." *C* imagined the magazine 'Truth,' visualizing the title very distinctly. Immediately afterward, *truth* was reproduced auditorily.

"It was an ele[m]ent of which the community was well rid. *L* imaged the *ele* of *elements*.

"The dogs were held in lea[sh]." *C* was not familiar with the term, *leash*. She had heard it before, once or twice at most. She "had a tendency to spell the word out."

"They went early to avoid the ru[sh]." To *L*, *went* sounded like *wept*. *Went* was finally confirmed by the context and was then visualized and auditized.

"The idea was very va[gue]." *L* visualized the word *idea*, and noted a tendency to put *r* on the end of it.

24. *With certain types of sentences the references of the various observers are approximately identical. These are usually* (*a*) *sentences in which the 'meaning' is unequivocal;* (*b*) *sentences in which a certain word or 'turn of speech' suggests a familiar proverb or stereotyped phrase; and* (*c*) *sentences which refer to local or common objects and events.*

This identity of reference was not met with frequently, and this fact leads one to doubt Stout's[2] conclusion that language as a means of communication "serves to fix the attention of the hearer on the ideally represented objects present in the mind of the speaker." At least such a statement is only part of the truth. Symbolic communication serves indeed to transmit the experience of the speaker to the hearer, but the manner in which the speaker's 'meaning' is taken by the hearer is conditioned entirely by the hearer's own experience. Language does not fix the attention of the hearer upon the experience of the speaker; it rather places the hearer in an ideally constructed experience which approximates—and generally only very roughly—to the experience of the speaker. This fact is more clearly shown under 25, below.

Illustrations: "By his si[de] crouched the faithful dog." *W*, *L*

[1] Dodge, R.: *op. cit.*, pp. 14-15.
[2] Stout, G. F.: A Manual of Psychology. London, 1899, p. 452.

and *Wb* all visualized a man with an ill-kempt dog cringing at his feet. In *L*'s visualization the man was represented as dead.

"A sulphur or a vapor ba[th] is recommended for the complaint." *L* and *Wb* imaged a vapor bath cabinet such as is advertised in the magazines.

"The evil will remain as lo[ng] as men are human." *L* and *C* immediately associated verbally the proverb, "To err is human, to forgive, divine."

"The bank was slo(p)ing." *L* and *W* misinterpreted *slo(p)ing* as *closing*. Each visualized a familiar bank building. *L* supplemented his visualization by the verbal associates, "Saturday, one-o'clock, too late."[1]

"The structure was simply stu[p]endous." *Wb* at first referred this indefinitely to Ramón y Cajal's schema of the chiasma. Later he visualized a 'sky-scraper' in New York. With the same sentence *L* visualized a Chicago 'sky-scraper.'

"The voca[b]ulary is an important part of the book." *L* and *W* referred this visually to the first Latin exercise books which they had used.

"They shou[t]ed lies to each other across seas of misunderstanding." *W*, *L* and *Wb* each supplemented this sentence with a visual reference to the ocean.

"They are goods which will wa[sh]." *W* visualized the interior of a store. A salesman was impressing upon a customer that the goods would wash. The counter was covered with blue ginghams. *L* visualized a similar scene, but not with such detail; he supplemented this with the verbal idea 'fast colors.' *Wb* visualized the interior of a store. The counter was a little to his left. The goods—cheap dress goods—were laid out in rolls. The clerk was bending over the counter and earnestly making the statement that the goods would wash.

25. *The imagery which apperception involves is not always consistent with the significance of the context; yet this does not necessarily mean that the significance is inadequately apperceived.*

The ideally reconstructed environment, if visual, may include objects the absence of which the speaker clearly intended the sentence to indicate; or there may be in the field of the apperceptive consciousness a complex of irrelevant elements. Stout[2] says that the "word only calls up what is relevant to the controlling interest of the thought," but what is relevant differs with speaker and hearer. In both cases it is determined by the 'personal equation,' by differences in experience, by the quality of the 'apperceptive' material.

Illustrations: "They were skating on the i[ce]." *L* visualized the surface of Lake Cayuga, unfrozen.

"The judge wore the ermine ro[be]." *Wb* visualized a man representing the judge, but the details of his costume did not come into clear consciousness.

"They were woven on an old-time loo[m]." *W* referred this to a modern woolen-mill.

"Pollu[ti]on of the ballot is the curse of democracy." Here *L* had a verbal reference to 'ballot,' but visualized muddy water.

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[1] *Cf.* Dodge, R.: *op. cit.*, p. 11.
[2] Stout: *op. cit.*, p. 462.

"The council chose the si[te] for the new building." *Wb* referred this in a vague way to the Common Council of Salem, Mass. He visualized a building in Ithaca, but not a public building.

26. *Distraction of the attention militates against the complete apperception of the meaning of the sentence. This distraction is frequently caused by some peculiarity in the mechanism of the sentence, such, e. g., as the mutilation of an important word.*

While this principle as formulated above is an induction from the introspective data, it would follow *a priori* from our conception of apperception as the functional aspect of attention. In many of the instances which are cited below, the observer has 'a vague idea' of what the sentence means. They might be called instances of an incomplete or partial apperception, and no small part of our communicative experience is probably of this kind. As a rule, however, both the efficient expression of symbols and the efficient interpretation of symbols are possible only under stress of the attention: the processes involved seldom become automatic, and when automatic fail to function with efficiency.[1]

Illustrations: "The evil will exist as lo[ng] as the race is human." *Wb* repeated the sentence mechanically, but it was characterized by him as "only words;" it aroused no associations. The attention was distracted throughout.

"It was a mo[m]ent that was most impressive." *Wb* "kept thinking of the voice; it sounded excited; had no apperception of the meaning."

"The cloth will fa[de] if exposed to the sunlight." *Wb* reports his attention at a low ebb. He did not hear *cloth* or *fade* until the sentence was finished. Afterward he visualized the place at his home where fabrics are bleached by being spread upon the grass and exposed to the sunlight.

"The la(d) was fresh from the country." *Wb* first supplied *lad*, which he reported, then *lass*; then he returned and substituted *lad*. This operation absorbed his attention, and he had no definite reference for the sentence.

"To win the be(t), he had sacrificed his good name and character." The attention of *Wb* was absorbed by the mutilated word *be(t)*. Although he finally filled it out correctly, he could not analyze the process. "There was present some sensory content, but it was very vague. The whole process appeared to be verbal."

"He left the prisoner to his fa[te]." *W* was distracted by the tone of the voice as reproduced by the phonograph, and did not apperceive the meaning of the sentence.

"The sermon was unconscionably lo[ng]." *L's* attention was centered upon *unconscionable*. He pictured the word in print, and referred to various efforts at [illegible] it. One man was visualized in particular. The general [illegible] of the sentence was entirely missed.

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[1] [illegible] 130,) has emphasized the importance of [illegible]: "Conscious experience is a constant [illegible] toward equilibrium between the auto- [illegible]. Errors, or lapses, appear in the re- [illegible] between these two processes."

27. *Familiarity with the sentence sometimes militates against a clear and definite reference on the part of the observer.*

Illustrations: "[D]eath is a beneficial thing, biologically." *Wb* had heard the sentence spoken into the phonograph, and after the first few words paid no more attention to it. "All associations seemed swallowed up by this one reference to the previous hearing of the sentence."

"The use of rou[ge] is pardonable only in the green room." *Wb* had already heard the sentence and "experienced a feeling of 'dead familiarity' with it." He had, however, a very vague visualization of the stage of a familiar theater; this was supplemented by the image of a woman of his acquaintance who uses perfumes.

"Obli[g]ing individuals are generally poor." *L* reports the sentence as having a 'familiar feel.' It aroused no definite reference.

"Be[y]ond matter is spirit." The thought was familiar to *W*, and aroused no definite reference.

28. *A characteristic feature of the apperceptive consciousness is the constant change of its pattern to meet the changes in the context.*

In many sentences, the reference which the first few words arouse is inconsistent with the succeeding parts of the context; the supplementing of one word or phrase fails to supplement the sentence as a whole: the observer is in one attitude, has one adaptation, at one point in the sentence; at another the attitude changes, there is a new adaptation and a new shift of the mental scenery.[1]

Illustrations: "That the man was brave, no one could deny." *Wb* first interpreted the sentence as, "That the man was gray, no one could deny." This was unsatisfactory and led to a new construction. *Brave* seemed to "struggle up from the inside of the head and come to the front."

"The wheel had worn a groo[ve] in the iron rail." *Wb* at first referred *wheel* visually to a bicycle. When *groove* was heard the reference was changed to the idea of machinery. When *rail* was heard, a railroad was visualized and later a street-car track.

"He had not yet lost fai(th) in the enterprise." *L* misinterpreted *fai(th)* as *a day*. At first he referred the sentence visually to a man diligently at work; this was before *enterprise* was spoken. With *enterprise* "the conscious reference assumed another setting which expressed itself in the thought that the man had put no time at all into the undertaking."

"The king's ro(be) was yellow." *L* misinterpreted *ro(be)* as *row*. He referred visually to the king's row of tombs at Westminster Abbey. Later *row* was apperceived as signifying a boat, and a long yellow shell was imaged.

"The fifty-ton sloo[p]-of-war captured a frigate." *L* referred this to a

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[1] *Cf.* Stern, L. W.: (Psychologie der Veraenderungsauffassung. Breslau, 1898, p. 147.) "However sovereign the spontaneity of attention is as regards constant sensations, it is just as dependent upon the changing ones. Determined by central factors, it directs itself toward the former; the latter compel it to themselves. They are themselves motives of the adjustment of attention."

naval engagement. He visualized Paul Jones with a 'cocked' hat. *Sloop* was supplemented by the visual idea of a single masted sailing-ship. This dropped out of consciousness with frigate, and was replaced by the idea of two large battle-ships.

"Several black ba(ss) were caught in the stream." *Wb* at first misinterpreted *ba(ss)* as *bear*. He visualized in this connection a small black bear and a forest background. When *stream* was heard, he substituted *bass* for *bear*. The forest setting still persisted, but a hook replaced the bear as a center-piece.

"The rai(l)ing was washed away." *L* misinterpreted *rai(l)ing* as *rain* and referred it to the visual idea of sand washed away by rain. Later *rain* was changed to *railing* and supplemented by the image of a ship on a very rough sea.

"The king was forced to be(g)." *L* misinterpreted *be(g)*, first as *bed* which he supplemented with the idea that the king must have been under the influence of some very strong character. Then *bed* was replaced by *back*, supplemented by the idea that the king was in danger of assassination; this took form in a visualization of a man coming before the king on horseback.

28. *When there is doubt of conflict as to the meaning of a sentence, the apperceptive consciousness is predominantly unpleasant. If the apperception of the meaning is clear and distinct, the affective tone is generally pleasant. This is apart from the intrinsic affective tone of the sentence as such, which may be pleasant unpleasant, or indifferent.*

Sentences the apperception of which was accompanied by a pleasant affective tone:

"That the man was bra[ve] no one could deny." *Wb* "felt satisfied" because he got the interpretation easily and correctly.

"Every one expected a dro[p] in the market." *Wb.* (Referred to a humorous incident.)

"Brute and ma[n] are one in their physical structure." *Wb.* ("Liked the sentence because of its length." The preceding sentences had been very short.)

"The re[v]elation of the universe may be variously interpreted." *L.* (No reason given.)

"Pou[r]ing oil on troubled waters causes them to subside." *W.* (No reason given.)

"The first horse had passed the po[le]." *L.* ("Thought of trotting race and horses neck and neck." When *pole* was heard he wished to replace it with *line*. Then he remembered that the term *post* was used in the same connection. This changed the affective coloring from unpleasant to pleasant.)

"Wi[th]out health, happiness is perhaps impossible." *Wb.* (Did not supply *health* until the sentence was completed. When it came it was accompanied by a pleasant affective tone.)

Sentences the apperception of which was accompanied by an unpleasant affective tone:

"He had lost ho[pe] in the unequal struggle." *Wb.* ("Felt sorry for the poor beggar.")

"The invalid should be fe[d] on weak broth." *W.* (Observer "dislikes broth.")

"By his si[de] crouched the faithful dog." *W.* (No reason given.)

"Sla[mm]ing doors is a trait of childhood." *W.* (No reason given.)

"Fi(r)ing too high is a common mistake." *C.* (Aggravated because she could not apperceive the meaning. She noticed a general tension in trying to get a word for *fi(r)ing*,—a strain about the eyes and chin.)

"The loss will be greater or le[ss]." *L.* (Proposition trivial.)

"The milk was brought in a ju[g]." *L.* (Unpleasantness came with the idea of milk, which was visualized a pale bluish-white fluid.)

"The idea was very va[gue]." *L.* (Observer reproduced ideally the condition he feels himself to be in when baffled by an idea. It is an unsatisfactory 'groping,' with a large affective coloring of unpleasantness.)

"The navy consisted of two ships and a bri[g]." *W.* ("It was so insignificant.")

"As a joke it was simply hu[ge]." *L.* (Last word uncertain. Feeling of bafflement, curiosity and disappointment, followed by pleasure when the word was finally supplied.) *Wb.* ("Had a 'motor laughter fringe' on hearing the sentence.")

In planning this investigation, we had intended to determine as nearly as possible the point in the sentence at which the apperception is completed. To this end, sentences were to be given to the observers, at first with the final word cut out, then the next, and so on until the implication of the sentence was entirely lost. Then the sentence was to be built up from the beginning, first one word being given, then another and then another until the 'thought' was complete. It was found, however, that this procedure would require a greater number of observers than was available; hence the test was left incomplete. The following statements may, however, be made: (1) The omission of the final word causes practically no disturbance to the apperception of the sentence, either the word itself or its meaning-equivalent being readily supplied by the observer. (2) Proposition 20 seems to indicate that apperception is completed early in the sentence. (3) Proposition 1 affords a certain confirmation of this hypothesis. (4) The whole trend of the introspection recorded during the second part of our experiment is to place the act of apperception early in the sentence.

We had also planned to determine the relative importance of the various parts of speech to apperception. So far as the mutilations are concerned we are able to say that 'contextual supplementing' is not a function of the syntactical character of the word.

29. *In general: The consciousness concomitant with the apperception of auditory symbols is made up of sensational and affective elements—some peripherally, some centrally aroused—in connections which vary in character with different individuals and under different conditions. These connections are arranged in patterns which change rapidly into one another, and are in general transitory and fleeting. When the attention is directed to the peripherally excited elements exclusively—when the external stimuli occupy the burning point of apperception—the meaning which they as symbols should convey is not clearly apperceived. When the attention is directed upon the centrally aroused ideas which the symbols suggest, the 'meaning' is apperceived, but errors and lapses in the stimuli are apt to pass unnoticed.*[1]

Stout[1] in his exposition of 'implicit apprehension' says: "The mental state which we call *understanding the meaning of a word* need not involve any distinction of the multiplicity of parts belonging to the object signified by it. To bring this multiplicity before consciousness in its fullness or particularity would involve the imagining of objects with sensory qualities, visual, auditory,

[1] Stout, G. F.: Analytic Psychology. London, 1896, Vol. I, Ch. iv, pp. 78 ff.

tactual, etc. But it has often been pointed out that in ordinary discourse the understanding of the import of a word is something quite distinct from having a mental image suggested by the word.'' And so the concept of 'implicit apprehension'—the apprehension of form without the apprehension of content—is introduced to explain the phenomena of symbolic apperception. Stout, however, goes too far when he says that there is "no absurdity in supposing a mode of presentational consciousness which is not composed of visual, auditory, tactual and other experiences derived from, and in some degree resembling in quality the sensations of the special senses; and there is no absurdity in supposing such modes of consciousness to possess a representative value or significance for thought, analogous in some degree to that which attaches to images, just as revived images may have a representative value in some degree comparable to that of sense-perceptions, in spite of very great differences in respect to distinctness, vividness and quality.'' From the series of observations which were made in the course of our experiment, no conscious 'stuff' was found which could not be classed as sensation or affection, when reduced to its ultimates by a rigid analysis. Neither do our experiments show that there is in the apperception of spoken sentences such a thing as 'imageless apprehension.' They show rather that the consciousness concomitant with symbolic apperception is in a state of attention, where certain constituents are clearer and more distinct and certain other constituents more obscure and less distinct; and that among the more distinct constituents, among those which occupy the focus of attention, there are always some—whether they be verbal, visual, kinaesthetic or what not—that are definitely tangible, and that can be reported by introspection.

It is true that Hobbes, Berkeley, and Dugald Stewart,—all of whom are quoted by Stout,—found it difficult to make the apprehension of symbols consistent with a sensational psychology. But these men lived and wrote before the function of the verbal idea in 'thought' processes had been thoroughly exploited; before its kinaesthetic nature had been pointed out; before the current doctrine of attention with its biological implications had been suggested; and before recognition and recollection had been differentiated in the memory process, and referred to spatially, structurally and genetically different areas in the brain cortex. It is now generally admitted that direct recognition does not necessarily involve the conscious comparison of the presentation with a memory image, and the subsequent formation of the judgment 'alike' or 'different.' And the apperception of symbols signifying bits of experience may, quite legitimately, involve a form of direct recognition, more

complicated, it is true, yet similarly devoid of any complex of visual images. But this does not imply that the apprehension is 'imageless,' in Stout's connotation of the term. Recognition is not a structural element, but a process in which certain elements unite to form the recognitory consciousness, to carry the function of recognition. But these elements are either sensations or affections. Stout's 'implicit apprehension,' on the other hand, postulates a non-sensational, non-affective element, —a schema, a form without content, a structural something that can in no way be reduced to modal elements.

The relation of apperception to attention suggests a biological significance that may do much toward clearing up these problems. Apperception is the functional side of attention, and attention is the mental aspect of organic adaptation.[1] The new is not apperceived by the old in the Herbartian sense: the new arouses a typical attitude, an attitude in which the organism faces the typical environment which the new symbolizes. We may say with Stout that the new is referred to a mental 'system,' in so far as such a system is a mood, an attitude, a tendency, an adaptation. The mind adjusts itself uniformly to uniform conditions: this seems to be the essence of the apperceptive 'mood.' When *C* in the sentence "The play was bad," interpreted play as a drama, her mind adapted itself in a degree to the drama environment. This was not necessarily a focal reference to a given play, but the mind was in the dramatic 'mood.' Should particular parts of a typical play-environment have been ideally reproduced, the situation would only have been reinforced. Should certain verbal ideas such as 'drama,' 'theaters,' 'Shakespeare,' etc., have been reproduced in consciousness, either visually, auditorily or kinaesthetically, these ideas would have been constituents of the dramatic 'mood,' but not necessarily the fundamental constituents. The fundamental constituents may and do vary from time to time. Only very seldom can they be called constant, and the 'constant supplements' which we have noticed are instances of such occasions. The fact that the focal constituents of the apperceptive consciousness are not necessarily consistent with the situation represented bears testimony to this point of view. "There was not room for a stove in the corner;" with this sentence one observer imaged distinctly a stove in the corner of a small, otherwise bare room. His own surprise at the inconsistency of this imagery was shown by his exclamation upon reporting the introspection: "But there *was* a stove there!"

In symbolic apperception, the function of language is to reproduce the appropriate mood, the consistent attitude, the more

[1] *Cf.* Titchener: *op. cit.*, ch. vi, pp. 118 ff.

or less uniform reaction, with which an organism would face a certain environment. Speaking broadly, we may say that each mental 'system,' each 'cortical set,' represents the adjustment of the organism to a particular environmental condition. Each adaptation marks a separate bit or pattern of experience upon the side of mind. In fact, experience might be considered as a mosaic, or rather panorama, of succeeding 'mental systems.' It is manifest that those organisms which have adapted themselves most readily and with the least friction have possessed, other things equal, the characteristics most favorable to survival. And so it is not surprising that we now find many 'short cuts' to adaptation and reaction,—that we find a verbal idea coming to represent a complex mental system, and reproducing in a condensed form all the essential conditions of a given environment.

This point of view also gives us a definite connotation for the term 'meaning.' Mind, from the beginning, has taken the form which the environment has given it.[1] The mental contents have always been 'meaningful' for the organism. A given complex of sensations is correlated with such and such a 'thing' of the outside world. The perception has such and such uses; the object is to be met by such and such adaptations. But the functions of the primitive mind were comparatively few. Each of its attitudes was self-sufficient. Every pattern was an independent pattern, and carried with it its own 'meaning' for the organism. But with the development of memory came the function of 'remote adaptation.'[2] The constant recurrence of given complexes in a multitude of different connections added something to the 'meaning' of a presentation: namely, the previous significance of similar presentations. As development continued and experience widened, the recognition of identity in 'meanings' became more and more automatic, became pushed back farther and farther into the margin of consciousness. In the adult apperceptive consciousness there is, as we have seen, no constancy in the quality and modality of the focal constituents. With very few exceptions—of which the 'constant supplements' are instances—the same symbol arouses at different times focal references which may be uniform or disparate, consistent or inconsistent; and yet the meaning of the symbol in combination with other symbols is perfectly unequivocal. It is reasonable to suppose that the marginal elements furnish the essential uniformity, and compensate the

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[1] *Cf.* Titchener, E. B.: A Primer of Psychology. New York, 1899, p. 197.

[2] *Cf.* Bentley, I. M.: This *Journal*, Vol XI, No. 1 (1899), pp. 14 ff.

apparent inconsistencies.[1] In other words, the consciousnesses that are correlated with like adaptations are similar, not necessarily in their focal, but in their marginal constituents. Interpreted as marginal constituents, the kinaesthetic factors as well as the organic sensations come to their true rights. When the observer's attention is centered upon the stimuli—upon the symbols—he is in a 'sentence' mood, or a 'word' mood, or a 'mutilation' mood: *i. e.*, there is a certain adaptation in which certain marginal factors are constant. But when the attention shifts to the symbolized situation, the mechanism of the sentence, as such, becomes obscured; there is a new adjustment, resulting in another adaptation, in which certain other marginal factors are constant. In the one case, the sentence is apperceived as an orderly complex of sound units; in the other case it is apperceived as, in itself, a 'meaningful' unit.

The margin and the focus of consciousness play—if the expression may be pardoned—the one into the hands of the other; but the nature and modality of the elements which are to come into the focus, and the pattern of the elements which are to remain in the margin, are determined by the needs of the organism. It is the peculiar office of apperception, as the functional side of attention, to interpret the new presentation in the light of its significance to the organism. If it be a complex of visual sensations, supplemented by certain tactual and motor associates, and by the verbal idea 'table,' it may 'mean' an object to write on or an object to eat from, an object to be sold or an object to be bought, according as the mind is adjusted to the situation. If it be an auditory or visual complex, "The play is bad," it may 'mean' a mere combination of forms, a forbidden lead at whist, or a poorly staged drama. In each of these cases the presentation is met by a totally different adjustment of the organism, correlated on the side of mind with a peculiar and fitting pattern of consciousness. In this pattern certain typical sensations—centrally and peripherally aroused—occupy the margin of consciousness. They are determined largely by the individual, and are constant with him for this type of adaptation. Certain other elements occupy the focus of consciousness. These are determined almost entirely by the

[1] *Cf.* James, W.: Principles of Psychology, N. Y., 1890. Vol. II, p. 49. "The meaning is a function of the more 'transitive' parts of consciousnesss, the 'fringe' of relations which we feel surrounding the image, be the latter sharp or dim." James's position is practically that which we have taken above, except that he has approached the question from the standpoint of epistemology, rather than from the standpoint of genetic psychology. As a rule, an appeal to genesis is much more satisfactory than an appeal to epistemology, as the history of the psychological space theories abundantly shows.

existing environment, or by the exigencies of the situation which is faced.

Nor is this point of view inconsistent with that[1] which gives to the kinaesthetic elements the duty of carrying the meaning of a presentation. Reaction to the environment was the primary function of the primitive mind. When the development of memory brought with it the complications arising from the consciousness of former experiences, the motor memories became of fundamental importance in the new 'remote adaptation.' In the adult consciousness, as we have studied it, even symbolic apperception involves adjustment and adaptation, and adjustment and adaptation involve motor reactions. The kinaesthetic elements are predominantly marginal elements and the marginal elements 'carry the meaning.'

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[1] *Cf.* Bawden: *op. cit.*, pp. 44 ff. Münsterberg's 'Action' theory of meaning must be left for a more detailed discussion. *Cf.*, in this connection, Münsterberg, H.: The Physiological Basis of the Mental Life. Science, N. S., IX (March 24, 1899) pp. 442 ff.; also Breese, B.: On Inhibition. *Psychological Review Monograph Supplement*, Vol. III, No. 1, pp. 47 ff.

MINOR STUDIES FROM THE PSYCHOLOGICAL LABORATORY OF WELLESLEY COLLEGE.

Communicated by MARY WHITON CALKINS.

IV. STUDIES OF THE DREAM CONSCIOUSNESS.

II.

By GRACE A. ANDREWS.

No psychologist has as yet discovered what every one of them desires: an experimental method of varying and repeating stimulations of the dream consciousness, which shall not at the same time vitiate the conditions of natural dreaming. The simplest method, that of giving the subject a definite stimulus just before he falls asleep, has been tested by Mr. Monroe[1] with visual stimuli and with tastes, and has recently been applied by the writer with visual stimuli. The subjects were six Wellesley College students, only one of them, however, the writer, trained in dream introspection. The materials were small squares of colored glass, about four by four inches, green and red, and illuminated from behind; similar squares of colored paper (a less adequate material); and two simple colored lithographs, one of a mounted horsewoman, the other of a woman surrounded by flowers. Just before going to bed the subjects of the experiment looked fixedly for five minutes at the colors, and for ten minutes at the pictures. The results are briefly these:

The trained subject has dreams on 3 out of 4 nights, probably suggested by the fixated colors or objects; and the average number of her remembered dreams is 5.4, as compared with an average of 3.4 on the nights of ordinary dreaming. One of the other subjects has these suggested dreams on two out of four nights, and has three cases of dreams which are possibly suggested by the experiment of a previous night. Of the other subjects there are two who have one dream each apparently suggested by the experiment; and, finally, there are two whose dreams seem unaffected.

For several reasons these experiments were discontinued before obtaining sufficient records for even a tentative conclusion. The inexperienced observers obviously required training in the observation and record of their normal dreams before the attempt to vary experimentally the conditions of their dreaming. There are, however, more fundamental difficulties which

[1] This *Journal*, Vol. IX, p. 413; Vol. X, p. 326.

seriously affect the value of such experimenting upon even the trained observer. There is the disadvantage attendant upon all investigation in which a person experiments upon himself; there is the further objection that stimulation and supposed result are separated by a considerable interval of time; and, finally, there is the lack of any observer of the attendant conditions.

The ideal method would provide for the excitation of the dreamer through auditory, olfactory or dermal stimuli, applied by the experimenter at different periods during the night. The practical difficulties, however, seem to be all but insurmountable. We have used, for instance, music boxes gently playing, intense and heavy odors, and cool surfaces for the immediate stimulation of dreams, but have failed in every instance, through prematurely waking the dreamer. Awaiting the more successful application of this method, or the discovery of a more effective one, there can hardly be too many records, by careful observers, of all their dreams during a series of nights. Such a record[1] of 118 dreams, was kept by the writer, during her second year of psychological study. The dreams were, with few exceptions, recorded continuously during six weeks immediately upon waking; the records were re-read upon the following day to discover their links with the waking life; and the records, as a whole, were carefully studied when entirely completed. The most significant results of the study may be summarized as follows:

Nearly 90 per cent. of these dreams are clearly suggested by the waking experience; more than one-half refer to occurrences of the same week, nearly one-half to the immediate environment, and two-thirds to people of the every-day life. Visual experiences predominate, as in the case of most dreamers, occurring in 96 dreams, that is in 81 per cent. of the total number. Nearly half of these dreams include color-sensations, and these have been a source of much æsthetic pleasure. On the other hand, only 7 dreams could be definitely remembered as containing ry sensations, and few of the conversations seemed to be heard.

ost dreams of apparent taste and smell, sight sensa- rly does duty for both the others. The records, how- ntain accounts of one clear, gustatory dream and of ollowing olfactory dreams: I was holding a can from me a vapor which the sponge absorbed. I soon be- oppressed by the strong, stifling choking odor, and how long I could stand it before becoming chloro- yself. (I woke from the dream almost immediately zed the experience as carefully as possible, remem-

[1] ghout M. W. Calkins, Statistics of Dreams. This *Journal*,

bered that I had had no dream of smelling while keeping the record, and went to sleep again.) I then dreamed of looking off in the direction of Milton and of thinking and saying that beyond lay the ocean. I immediately got the keenest and most natural smell of wind from the flats and the delicious ocean odor. This gave me such intense pleasure, as it always does, that I awoke. (This dream, like the other, was carefully thought over upon waking, and seemed even more clearly to contain a pure and rich sensation of smell.) The following is the record of the taste dream: "Feb. 25, after 2.30 A. M. Dream 148. We were, I think, at the house in L, where we lived, eight years ago. We had a new kind of bluing; I saw some of it in blue streaks in the water. Father had put some in a well from which our drinking water came. I thought it was deadly poison and did not see how he could have been so careless. I had drank some of the water before I knew. It had a horrid metallic taste (like the taste of copper sulphate, which I got during the fall, from a drop on my blotting-paper).

The dreams seem, also, to include discomfort rather than physical pain. In a dream of being bitten by a kitten, whose red, open mouth I saw . . . I could not recall that I had suffered any pain. The experience seemed a complex of visual and tactual elements of an extreme intensity, rather than pain.

The frequent emotions of these dreams are, all of them, nearly as vivid and strong as those of the waking life, and many of them are stronger. Indeed, the dream emotion seems to me the most real element of the dream life and the one most to be depended on to follow the laws of waking consciousness. Although 29 of the 50 distinct and namable emotions are classed as unpleasant, yet the general affective impression of the dream, as a whole, was usually pleasant, perhaps because of the interest in the change of scene and the pleasant uncertainty of 'what next.' Æsthetic pleasure, also, often questioned as a dream-experience, forms an important part of dream pleasure, especially in dreams of color and of nature.

There are 34 clear instances of reasoning and argument—usually, of course, on absurd or trivial premises. In dream 13, for example, seeing "a doll which went by clock-work and was attached to a little cart, drawn by dogs which ran alongside," I "wondered how the machinery was regulated so that the doll just kept up with the dogs and what would happen if they ran faster." The composition, in dream 69, of the word 'Orthogeneous' in opposition to 'heterogeneous' is another case of reasoning, quite distinct from the mere association of words through *similar sounds.*[1]

Besides the natural association with each other, of the objects and events of these dreams, there is a frequent tendency

[1] *Cf.* James Sully, Illusions, c. 7, p. 181, note.

to connection between dreams of the same night. Thus, dreams 1 and 2, though of a totally different character, are both enacted on the deck of a steamer; and dream 3, of a vegetable garden, is followed by a dream of lettuce. This relatively uncontrolled association of the dream-life is responsible, of course, for the dream-story. There seems to be a close analogy between the way in which the events of the dream-story are evolved from our own imagination, with no plan or foreknowledge on our part, and the relation of the novelist to his characters, which in many instances assume a personality, speak, act and arrange their own destiny, almost without his control. The writer's dream-story is often both seen and heard as if read aloud by herself or another. Its events often have an unusual consistency, showing some unifying control by the mind. Often, also, it involves the phenomenon of so-called Double Identity. This may consist, in its simplest form, in merely watching the action of another (which is, nevertheless, my own dream-consciousness), or it may be something so complicated as to baffle description, the dreamer being at once spectator and actor and sharing in the emotions of each, as in the following dream: "Jan. 15, 5 A. M. Dream 35. A woman was being married in a cave, according to the ceremony of some savage tribe. I was, in quick succession—or at the same time, as it seems,—the woman herself and a spectator. The ceremony was connected with a magic stone, at first, small, greenish, with red spots, afterward larger, irregularly shaped. Then I was going down a street in Boston. When I reached a certain house, a very small man—the husband—appeared and led me up the steps and up a flight of stairs. After going up stairs, the woman or myself—I was both actor and spectator—threw herself into his arms, but the man was so small—a mere small boy—that he was overpowered by the onslaught, lost his balance and nearly fell to the floor. In my character of spectator I saw the ludicrous side of this, laughed and thought it very funny."

It will be observed that this dream involves no real 'change of identity.' The self of the dreamer is by turns observer and heroine, but does not disappear, however bewildering the change of circumstance. Indeed, these records confirm at all points every careful study of the dream experience. All such records disclose the intense individuality of the dream-life—even less susceptible than the waking experience of reduction to rigid general laws; they manifest also its inherent absurdities, due, of course, to the absence of waking criteria of reality; on the other hand, they bear unequivocal testimony to the presence in the dream-life of thought, moral reflection and æsthetic emotion as well as sensation and primitive feeling, and to the integral unity of the dreaming with the waking consciousness.

THE RELATION OF STIMULUS TO SENSATION. A REPLY TO MR. MAX MEYER'S CRITICISM ON PROF. C. LLOYD MORGAN'S PAPER.

By Prof. F. R. Barrell.

The July number of this *Journal* contains a criticism by Mr. (? Prof.) Meyer on a recent paper by my colleague, Prof. Lloyd Morgan. It is stated that "the mathematical discussion contains several errors;" as I was responsible for a certain amount of advice in the preparation and for a final confirmation of the expression of Prof. Morgan's views, I have volunteered to reply to the criticism.

Mr. Meyer ought to have recognized that the whole sting of his criticism depends on a question of Definition. A circle, ellipse, or hyperbola has each its definition consecrated by time: a logarithmic curve, sine curve or the like has not. For the purpose of the paper under discussion we defined a 'logarithmic curve' [and the definition is obvious from the context][1] as one in which the "ordinates are in Geometrical Progression when the abscissae are in Arithmetical Progression" or *vice versa:* that is, the curve represented either by $y=Ae^{Bx}$ or by $y=A \log Bx$.

This curve is a direct expression of the Weber-Fechner law, it stands in a definite relation to the axes of co-ordinates—*i. e.*, in our case to the lines of no-sensation and no-stimulus—it has the essential and to my mind objectionable property that it cannot pass through the origin and it cannot embrace the obvious fact that no-stimulus is accompanied by no-sensation.

Further, the language of Prof. Morgan's paper distinguishes between a 'part of a curve' and the 'complete curve:' this is in accord with my own habit; thus, I would not call a Gothic arch circular though it be composed of arcs of circles; nor would I call the curve of cosines the curve of sines, though it be merely the same curve in a different phase. This habit may not be as general as we imagined, and I would not seek to impose it on Mr. Meyer.

Prof. Morgan enunciates the law A "*Equal increments of*

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[1] Prof. Morgan's phrase "*logarithmic, as it should be, if the Weber-Fechner formula holds good,*" may fairly be claimed as an explicit statement of the definition, for the curve $y=Ae^{Bx}+C$ is *not* 'as it should be,' if the Weber-Fechner law be true.

sensation are produced by increments of excitation in Geometrical Progression."

The Weber-Fechner Law B may be tersely enunciated "*Sensations increasing by equal increments are produced by excitations in Geometrical Progression.*"

Mr. Meyer overlooks the fact that law A is merely a particular case of law B, and, moreover, that it is the only case which cannot possibly hold good in the lower stages of sensation.

In my note to Prof. Morgan's paper[1] I showed how the mathematical expression of his law led to the Differential Equation

$$\frac{dy}{dx}\,\frac{d^3y}{dx^3} = \left(\frac{d^2y}{dx^2}\right)^2 \quad . \quad . \quad . \quad \text{(I)}$$

it is easy to show that the Weber-Fechner law leads to the equation

$$y.\,\frac{d^2y}{dx^2} = \left(\frac{dy}{dx}\right)^2 \quad . \quad . \quad . \quad \text{(II)}$$

Mr. Meyer must know the fundamental distinction between an equation of the third order and one of the second: viz.—the solution of one contains *three arbitrary constants*, that of the other contains *two*.

Thus

$$\text{(I) leads to } y = Ae^{Bx} + C = A10^{bx} + C \quad . \quad . \quad . \quad \text{(III)}$$

$$\text{(II) leads to } y = Ae^{Bx} = A10^{bx} \quad . \quad . \quad . \quad \text{(IV)}$$

the similarity between these two results, and the accident that by putting C=o, or by adjusting the axes, III reduces to IV, ought not to blind us to the above essential difference; nor ought we to be influenced by the fact that any arc of III can be superposed in Euclidean fashion upon the corresponding arc of IV.

The advantage of possessing three arbitrary constants A, B, C as in (III) is seen as follows:—Since any arbitrary scales may be chosen for representing stimulus and sensation, it is conveni[illegible] each experiment to represent the extreme sensation [illegible] stimulus each by 100: Thus III must be satisf[illegible]=100, x=100:

$$\therefore 100 = A10^{100b} + C \quad . \quad . \quad . \quad \text{(V)}$$

[illegible]xiomatic that 'no-stimul[illegible]s' is accompanied [illegible] [this may be a psycholog[illegible]cal blunder; if so, a[illegible]

[1] [illegible]al Review, VII, No. 3, pp. 2[illegible]7-233, 1900.

mathematician I must be pardoned], hence III must be satisfied by y=o, x=o

$$\therefore \quad 0=A10^0+C \quad \therefore \quad c=-A$$

which by substitution in (V) gives

$$100=A10^{100b}-A$$

$$i.\ e.\ 100=A\ (10^{100b}-1) \quad . \quad . \quad . \quad (VI)$$

this single relation between A and b leaves at our disposal one other relation betweeu them, and this we utilize to give character to the sensation under discussion by making the curve pass through any single point determined in the experiment: in the case of White on 'Morgan's Black' this was the point y=27, x=50 giving

$$27=A\ (10^{50b}-1) \quad . \quad . \quad . \quad (VII)$$

in the case of Red on 'Morgan's Black' it was y=35, x=50, giving

$$35=A\ (10^{50b}-1)$$

Equations VI and VII determine the values A=15.85, b=.008639.

If we attempt to treat formula IV in the same way, we begin as before:—put y=100, x=100

$$\therefore 100=Ae^{100b} \quad . \quad . \quad . \quad (V^1)$$

now put y=o, x=o

$$\therefore 0=A10^{0.b} \quad . \quad . \quad . \quad (VI^1)$$

Unfortunately this cannot be satisfied by finite values of A and b, and we are confronted by the fundamental objection to the Weber-Fechner law—it cannot be applied to the low stages of sensation. But supposing even that (VI^1) could be satisfied by finite values of A and b, then V^1 and VI^1 between them would use up both the available constants, and we should have no constant left with which to give character to the particular sensation under investigation.

This point is brought out clearly by Prof. Morgan in his Fig. 4 in a comparison (which Mr. Meyer erroneously condemns) between the curve derived from his own experiment and the 'logarithmic-curve-as-it-should-be-if-the-Weber-Fechner-formula-holds-good,' which fits it most closely.

This family of curves being represented by $y=A10^{bx}$, any member of the family is completely determined by two given points. How were these two points to be selected? As explained above, the desirable point y=o, x=o had of necessity to be abandoned: then in order to secure some degree of proximity between the curves the other extreme point y=100, x=100 was abandoned: finally, as clearly stated by Prof. Morgan and *quoted by Mr.*

Meyer the stages 6 and 14 were selected for coincidence: from the tabulated results we have

at stage 6 $y=13$, $x=30$ $\therefore$ $13=A10^{80b}$
at stage 14 $y=48$, $x=70$ $\therefore$ $48=A10^{70b}$.

These give $A=4.881$, $b=.01418$, hence the equation to the broken curve is $y=4.881\times 10^{.01418x}$ and, on the assumption that Prof. Morgan's black gives a reasonably approximate zero of stimulus as a basis for calculation, the contrast between this broken curve and the experimental curve illustrates well the difference between the new law and the old.

The latter part of Mr. Meyer's paper is interesting, as it brings out the simple mathematical fact that any member of the family of curves $y=A(10^{bx}-1)$ may be converted into any other one by a suitable increase or decrease of both the horizontal and vertical scales of representation: this property is so familiar in the case of ellipses and certain other curves that it did not seem necessary to call attention to it. Moreover, I cannot see that Mr. Meyer's method of comparing the results 'White on Black,' 'Red on Black,' 'Blue on Black' by adjusting the scales of the second and third so as to make them coincide with positions of the first, is intrinsically superior to Prof. Morgan's method of comparison by means of three distinct curves bridging over the same interval.

Mr. Meyer's method may, however, be the better if his suggestion be correct that the thing dealt with in the experiment was intensity of illumination rather than toning of color; this idea had previously suggested itself to Prof. Morgan, who said in his paper "so far as the colors are concerned the results appear to be due rather to the relative intensities of stimulation or excitation of the retina than to the effects of color as such."

The only fault which I can detect in Prof. Morgan's exposition of his results is that he neglected to point out the patent fact that by assuming (without any experimental basis for the assumption) that his black contained precisely 15.8% of white and 40.8% of his red (or of their illuminations) he would bring his results in line with the Weber-Fechner formula: this omission left it open to Mr. Meyer to assume that the fact had not been noted.

In conclusion I must add that even if the law "*Equal increments of sensation are produced by increments of excitation in Geometrical Progression*" be merely considered as a modified statement of Weber's law, yet it is a very material improvement on the old mode of expression, for it deals with the only things which are actually estimated in these and similar experiments, where the true zero of stimulus is difficult to ascertain, namely, *increments* of stimulus and *increments* of sensation.

Further, although the formula $y=A\ (10^{bx}-1)$ may not stand the ultimate test of being applied to low stages of sensation in cases where the zero of stimulus can be absolutely ascertained (as, *e. g.*, in estimating saltness of dilute solutions) yet it has the *prima facie* advantage that it permits us to work downwards without break of continuity to the point "no-stimulus, no-sensation," and that, as Prof. Morgan pointed out in his paper, it gives near the threshold of sensation an arithmetical progression of stimulus, which accords with results obtained by the pupils of Hering.

I am, of course, aware of the accepted opinion that starting with no-stimulus, and gradually introducing stimulus, some finite stimulus must be reached before any sensation is recognized; this seems to indicate some discontinuity at the inception of sensation, and might necessitate a corresponding discontinuity in the formula representing it. Yet, although some such explosive origin may be possessed by sensation, the hiatus between the zero and the starting point of sensation must be so slight, that it is desirable if possible in this, as in physical phenomena, to bridge over the hiatus by a formula which will extend down to the origin.

PSYCHOLOGICAL LITERATURE.

Psychologische Schulversuche mit Angabe der Apparate. HOFLER und WITASEK. Barth, Leipzig, 1900. pp. viii+30.

The above is, we believe, the first collection of elementary psychological experiments published in German. It consists of directions for seventy-five simple experiments, and is designed for use in gymnasia, normal schools, and similar institutions where students begin the subject. For the sake of having some systematic order of presentation the authors have followed the *Psychologie* of Höfler, and cross references are made to both the larger and smaller forms of that work. The experiments have all proved their value in actual teaching, and can be performed with a minimum of apparatus—a considerable number without any. Several are new in form and a few in substance. A list of standard apparatus (with prices as furnished by W. J. Rohrbeck's Nachfolger, Wien I., Kärntnerstr. 59) is appended. The collection is one that should prove valuable to any one engaged in teaching elementary psychology. E. C. S.

On a Flicker Photometer. OGDEN N. ROOD. Science, N. S. VII, 1898, 757-759.

On Color Blindness: On the Application of the Flicker Photometer to the Quantitative Study of Color Blindness. OGDEN N. ROOD. *Ibid.*, 785-786.

On the Flicker Photometer. OGDEN N. ROOD. American Journal of Science, Ser. 4, VIII (1899), 194-198.

On Color-vision and the Flicker Photometer. OGDEN N. ROOD. *Ibid.*, 258-260.

The first and third of these papers describe means by which Prof. Rood's flicker method of photometry may be applied to colored lights, as, for example, those of incandescent lamps, and give experimental data showing the accuracy of the method.

The second and fourth are of more immediate interest to students of color-vision. In the second paper are given results of measurements by the flicker method of the relative brightness of red and green lights ...een by observers known to be defective in the vision of red as com- ...h the brightness of the same colors as seen by Prof. Rood ...he differences are of striking amount, the color-blind ...nding the red and green lights respectively about 20%, and ...t as they seemed to Prof. Rood, on the assumption that he ...r observers were equally sensitive to violet blue. Another ...rtially red blind, saw red about 63% as bright as Prof. ...urth paper gives the results of tests by the same method ...s of "normal" observers. These also showed distinct ... the relative brightness with which they saw red, green, ...ue, though the degree of difference was in most cases ... with the green in the former cases. Classified with ref- ...1, they form two pretty distinct groups: one in which ...ompared with red and violet blue, and the other in ...ger than either. It would seem that Prof. Rood has ...stigation the same differences of "normal" vision as

have previously been noted by Rayleigh and Donders (see Helmholtz, *Optik*. 2te Aufl., p. 359), and that his flicker photometer offers a particularly convenient method of investigating them. E. C. S.

The Behavior of Unicellular Organisms. H. S. JENNINGS. Biological Lectures from the Marine Biological Laboratory of Woods Holl, 1899. pp. 93-112. Seventh Lecture.

Studies on Reactions to Stimuli in Unicellular Organisms.—VI. On the Reactions of Chilomonas to Organic Acids. H. S. JENNINGS. American Journal of Physiology, III, 1900. 397-403.

Reactions of Infusoria to Chemicals: A Criticism. H. S. JENNINGS. American Naturalist, XXXIV, 1900. 259-265.

In the first of these papers Dr. Jennings considers the behavior of unicellular organisms with a view to determining whether their movements are of such a character as to explain the migrations of cells in the embryo as some embryologists have been ready to assume. In the course of his discussion the author formulates his observations with reference to the activities of these low forms in a clear and interesting manner, illustrating them chiefly by the behavior of paramecia. Three forms of activity are found: "(1) One is the thigmotactic reaction. Starting with the moving infusorian, we find that it reacts to contact with solid bodies of a certain physical texture by suspending part of the usual ciliary motion, so that locomotion ceases and the organism remains pressed against the solid." "(2) If we start with the resting individual, the simplest reaction to a stimulus is the resumption of the usual forward motion. This is the reaction that is produced when the solid substance against which the creature is resting is removed; it is also produced in some infusoria when the posterior part of the body is stimulated mechanically." "(3) The third, and, for our purpose, most important reaction, to which most of the so-called tactic or tropic phenomena are due, may occur in either active or resting animals. It is a reflex consisting of the following activities: the animal swims backward, turns toward one structurally defined side, then swims forward. This reaction is produced by chemical stimuli acting upon any part of the body or upon the entire body at once, by osmotic stimuli, by heat, by cold, by mechanical shock. Its general effect is to take the organism out of the sphere of operation of the agent causing the stimulus, or to prevent it from re-entering." These creatures therefore have a crude adaptation of reflex movements to the nature and place of the stimulus received. Their movements are neither on the one hand the result of mere chemical or physical attractions or repulsions, nor on the other of complex psychic conditions, but are "of the same order as the motor reflexes of higher animals." This is a somewhat different and doubtless better considered statement than that of the author in the final paragraph of his article in this *Journal* (Vol. X, 1898-99, p. 515) where he speaks of them as "comparable in all essentials to those of an isolated muscle." The activities of unicellular organisms being of this reflex character and not of the more purely chemical and physical sort, the writer is inclined to decide against their being useful in solving the original question of cell migrations in the embryo.

The other two papers mentioned above are more or less controversial and devoted to clearing up differences between the observations of the author and those of Garrey, who has also published along nearly the same lines. The author seems successful in showing that the observations of Garrey are in accord with his own general principle quoted as (3) above. E. C. S.

COMMUNICATION.

To the Editors of the *American Journal of Psychology*,

GENTLEMEN:

I regret to say that through inadvertence no mention was made in my recent paper on "The Psychology of Conjuring Deceptions" of Professor Joseph Jastrow's important study of the same subject (The Psychology of Deception, *Pop. Sci. Mo.*, 1888, Vol. XXXIV, pp. 145-157).

Professor Jastrow was, so far as I know, the first to enter upon this field, and subsequent investigators naturally find themselves under obligation to him. The writer's attention has also been called to the fact that through Dessoir's lack of acknowledgment to this same author several citations have been credited to Dessoir that are to be found in Jastrow's original paper.

Respectfully,
NORMAN TRIPLETT.

Clark Univer ity, Sept., 1900.

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THE NECESSITY FOR A NEW STANDPOINT IN SLEEP THEORIES.

By HENRY HUBBARD FOSTER, A. B. Cornell University.

Sleep theories have suffered from two great lacks, lack of community of work and lack of systematization. Although many valuable researches have been made upon the physiological conditions of sleep, the work so far has been scattered and carried on, for the most part, by specialists in their own departments, without a proper realization of the breadth of the problem or the interrelation of its various phases. Recent theories have shown a tendency to combine elements from the three main lines of investigation followed, but such systematization has not been carried far. It is the object of the present article to subject the factual basis of the vasomotor, the chemical, and the histological theories of sleep to as thoroughgoing and impartial criticism as possible, and to show the exact relation of each to the problem in hand. In attempting this it has been necessary to treat the subject from the evolutionary standpoint. The theory presented in the concluding chapter claims nothing of finality. It is not our purpose to add another to the already too numerous theories of sleep, but rather to gain a new point of attack,—which we believe to be the only point of attack that offers promise of a solution of the problem.

I. THE CIRCULATION THEORIES.

The phenomenon of sleep has never received the attention that, from its importance to life, it deserves. As with all scientific problems which have been of general interest to mankind,

serves as a warning of the danger of attempting an explanation of a physiological state by reference to a pathological state that bears to it only superficial resemblances.[1]

The next theory to gain general ground was still a theory in terms of blood circulation, but was directly opposed to the preceding, in that it attributed sleep to cerebral anæmia. Before attempting any general statement or criticism, we shall first treat of its history. Blumenbach,[2] in 1795, advocated the diminution of the circulation of the blood as the proximate cause of sleep. His conclusion was based upon an observation on the volume of the brain in a young man who had fractured his skull by a fall. The opening remained covered only by the membrane. During sleep the chasm was deep, in waking hours superficial. In 1821, a case of fractured skull in a Montpellier woman was reported,[3] and later another case by Kennedy, confirming Blumenbach's observations.[4] The first attempt at experimentation was made by Donders (1854), who cut away a piece of the skull of an animal and examined the condition of the cerebral vessels through a watch glass cemented over the hiatus. He discovered the condition to be that of anæmia. Kussmaul and Tenmer in Germany repeated the experiment. In 1855, Fleming reported that the compression of the carotid arteries on himself and other subjects produced a dreamlike state of consciousness, while compression of the jugular veins resulted in an entirely different state.

So far these experiments and observations were scattered and had not attracted general attention, yet together with the other objections that could be urged, they were sufficient, in many quarters, to shake confidence in the congestion theory. A few of the writers who treat sleep at all were favorably impressed with anæmia, while many others grew non-committal. The time was now ripe for the more thorough and convincing investigations of Durham and Hammond. As has frequently happened in the history of science, these experiments were carried on independently and almost at the same time. Durham was the first to publish. His monograph on the Physiology of Sleep marks the beginning of a new epoch in the study of sleep problems. It justly deserves to rank as a classic.

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[1] With this theory can be associated such names as Cabanis, Bedford-Brown, G. H. Lewes, Metcalfe, H. Holland, Marshall Hall, Clutterbach, Sieveking, Dickson, Macnish, and W. B. Carpenter (in his earlier writings).

[2] Bluemenbach: (Tr.) p. 199.

[3] According to Durham the Montpellier case was reported by Caldwell, according to Hammond by Dendy. I have not been able to find the original.

[4] For other cases of fractured skull see Brown, Hammond (1869), Mosso (1880).

central or peripheral, or through the vascular system, *e. g.*, by decrease in force or frequency of heart beat.

Durham deserves much credit for the wide range of facts on which he bases his conclusions and for his scientific caution; but it is evident that his theory does not go far towards an explanation of sleep. It is fairly bristling with special problems, and is made up of elements that call for greater systematization and subordination. Traces of three more or less distinct lines, which investigators have subsequently followed, are visible: (1) the effects of auto-intoxication, (2) the necessity of oxygen to cerebral activity, and (3) the study of the mechanism by which the vascular changes are brought about. The first two tend to theories which emphasize chemical activities and reduce alterations in circulation to the role of a secondary factor. Hence we shall postpone consideration of the auto-intoxication, and a general discussion of the necessity of oxygen, until we come to treat of the chemical theories. An important point to notice about Durham's theory, and one that has been generally overlooked, is that he never definitely commits himself to more than the statement of a mutual interdependence of the condition of the brain and the condition of the circulation. He does not state whether cerebral anæmia is the cause or a result of cerebral inactivity.

Wm. Hammond's attention was first directed to the anæmic condition of the brain during sleep by a case of fractured skull in 1854.[1] His experiments (1860) were of the same character as Durham's, although not as extensive except upon the influence of anæsthetics and narcotics on the circulation. They yielded like results.[2] Later by means of a manometer he conclusively demonstrated that the blood pressure on the brain is less during sleep.[3] Hammond makes little attempt at theory. After pointing out the chief differences between sleep and stupor, he attributes the exciting cause of sleep to the necessity for nutrition and the removal of waste, the immediate cause to cerebral anæmia. This influence of anæmia is shown by the action of the heart, which draws the blood from the internal organs, including the brain, to the skin, thus causing sleepiness; by the action of extreme cold, which produces similar effects; by the action of digestion, which draws the blood to the alimentary tract; and by the tendency to sleep as exhibited in debility and excessive

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[1] For Hammond's works, see Bibliog. at end.

[2] For other experiments, see Vizioli, Mosso (1880). Tarchanoff (1894) has recently by experiments on young puppies entirely eliminated the possible factor of chloroformization.

[3] Hammond (1869), appendix. Weir Mitchell's experiments confirm.

loss of blood. Although unelaborated, this is a clear statement of the vasomotor theory.[1]

Investigators of sleep phenomena now became more numerous. Their work, however, was still characterized by little community of labor. It will hardly be profitable to treat of all the investigations and all the theories of the vasomotor type in chronological order. We shall content ourselves, therefore, with picking out a few of the most typical.

Girondeau (1868), making use of the discovery by Boll and Robin of the lymphatic spaces around the cerebral vessels, attempted, in a rather fantastic fashion, to account for the retardation of the blood circulation by a compression of the vessels due to an accumulation of lymph. J. Leonard Corning (1882), in studying the connection of throbbing carotids with epileptic attacks, invented an instrument for carotid compression. Through its means, he found that a certain degree of compression in the evening was much more efficient in the production of sleep than in the morning. Arguing from this fact to the conclusion that the flow of oxygenated blood was in each case the same, he is led to seek the primary impulse to sleep in the exhaustion of stored intra-ganglionic material. The continuance of function depends upon the amount of this material. But there is another physiological factor, which, although following in time, is of equal importance with the first. The explosion of plastic material is immediately dependent upon the circulation which brings the oxygen supply. Other things equal, intensity of function is in the ratio of the blood supply. Corning thus correlates the two factors of exhaustion and anæmia.

A distinct advance towards a closer grappling with the problem can be seen in the work of C. A. Moore (1871). He attempts to account for the onset of sleep by a discharge of stimulating influence from certain ganglia of the sympathetic
the neck along the vasomotor nerves of the cerebral
discharge occurs when the cerebro-spinal sys-
atigue of the brain, is no longer capable of
mpathetic ganglia. Its effect is the reduction
ly below the amount necessary to maintain
, but not below the amount necessary for
's theory is open to objections that make it
le. Its refutation, however, is important in
le lines of explanation that might be at-
ere is no such inherent antagonism between

he more usual term vasomotor, from the most typ-
place of anæmia theory.

aldson. The experiments of Franck, 1894, p. 721,
ald, 1896, p. 389, are to the point.

the cerebro-spinal and sympathetic as Moore assumes; (2)[1] although high authorities have been led to believe in a special vasomotor system in the brain, the weight of scientific opinion at present is against any such system. But, however this problem may be settled, we have the strongest kind of experimental evidence that both the total amount of blood in the brain and the rapidity of flow depend chiefly upon conditions of general blood pressure.[2] Until that evidence is shaken, the probabilities are all in favor of a vasomotor theory that explains cerebral anæmia by a loss of tone in vasomotor centers. Such a theory is that of Howell (1897). It is the most recent and by far the strongest presentation of the vasomotor theory yet made. As such, it demands detailed criticism.

Howell's point of attack is gained from experiments performed on the dilatation of cutaneous vessels during sleep. A water plethysmograph was attached to the forearm of the sleeper, with the no-pressure point kept at the middle part of the portion immersed. Great difficulty was at first found in sleeping under such unusual conditions, and it was necessary, to gain satisfactory results, for the subject to fatigue himself by considerable out-of-door exercise or by light sleep on the previous night. The experimenter kept a record of the various conditions of the sleeper, and their effect on the curve. As soon as the subject lay in bed and attempted to go to sleep, the experiment began. The curve fell—the exact moment of the setting in of sleep was impossible to determine—until it reached its minimum in one to one and one-half hours, where it remained with minor oscillations for an hour or two. A quite gradual rise now commenced, growing more rapid for the half hour just preceding complete awakening. Besides the general course of the curve, there were two classes of oscillations noted: (1) short, brief, variable oscillations usually traceable to external stimuli or movements, (2) nearly hourly periodic waves probably due to rhythmic changes in the vasomotor center. Howell's experiments number twenty in all. Mosso has also made observations proving an increase in the volume of the lower limbs during sleep and a corresponding decrease during mental activity,—results which, before Howell, were confirmed by Bardeen and Nicols, and by Dr. Shields in the Johns Hopkins laboratory. Durham can be quoted in favor of dilatation of the skin vessels. He based his conclusion chiefly upon the increase of temperature at the surface, which can be seen even by the unscientific observer in the flushed condition of the skin, and upon the observations ot Sanctonus, Keill and Edwards, which

[1] Foster, 5th Ed. Pt. III, pp. 1131 ff. Also, Pt. III, 1897. Mosso.
[2] Hill: 1896, pp. 40 ff.

involved in the production of sleep. Two other factors, singly or together, may co-operate with anæmia: (1) a diminution of irritability, caused by fatigue of large portions of the cortical area (particularly sensory and association areas); and (2) voluntary withdrawal of sensory and mental stimuli, involved in preparation for sleep. For lack of experimental data, Howell refuses to add, as Durham and Corning did, chemical elements to his theory, or to discuss the exact relation of blood supply to functional activity or quiescence of the organ. His theory is by far the strongest presentation of the vasomotor theory yet made.

The main point of criticism is the importance attached by this theory to the fatigue of the vasomotor centers. There are two lines of attack. (1) The plethysmographic curve commenced to fall as soon as the subject assumed a horizontal position in bed and attempted to go to sleep. The curve for arterial pressure shows a similar fall under the same conditions. But these results need not be interpreted to be due wholly to loss of tone of the vasomotor cells of the bulb, for such a fall occurs whenever the subject assumes the conditions of rest. In Hill's experiments, the arterial pressure was as low in the waking state, when the subject lay in bed in the morning, as in the sleeping state in the evening. The horizontal position tends always to lower arterial pressure.[1] The absence of movement in the limbs also contributes to the same result, since it removes two important factors (the compression of the muscles and changes in position) in the return of the blood through the veins. These considerations emphasize the importance of purely mechanical and reflex causes in the circulatory changes of sleep. (2) A decrease in tone undoubtedly occurs in the vasomotor center,[2] but this loss of tone is by no means confined to that center. The other bulbar and spinal centers share it in common.[3] All reflexes are slow and less intensive.[4] At the periphery the decrease can be seen in the perceptions of dullness in the forehead and eye-lids, tingling in the conjunctiva, feeling of feebleness in the voluntary muscles, etc., which often precede sleep.[5] The nerves alone remain unaffected in their capacity for functioning.[6] The condition of the vasomotor center is, then, only one manifestation of a phenomenon, general throughout the nervous system. A search for the causes of this phenomenon leads to a general discussion of organic

[1] Hill: Lancet (1898), Jour. of Physiol. (1898). I can see no way of reconciling Hill's A. M. results with Howell's.

[2] Conclusively demonstrated by Patrizi, 1897.

[3] Manacéïne: pp. 20 ff.

[4] *Cf.* Lombard's knee-jerk experiments, 1887.

[5] Berger and Loewy.

[6] Bowditch (1890) has established the fact that nerves can function indefinitely.

rhythms, and of the relative importance of central and peripheral fatigue to the integrity of the nervous system. By the same evolutionary sanction that has given the nervous tissue control over the metabolism of all other tissues, the higher brain centers have gained domination over the periphery.[1] The cortical cells are chemically the most complex in the body.[2] The demands placed upon them for the maintenance of consciousness are heavy and irregular. While we may not exclude fatigue of the periphery as a possible factor, it is surely much more true to the known facts to look to fatigue of the higher centers and the necessity for their recuperation as the main determining element both in the time of occurrence and the duration of sleep. The initial loss of tone in the vasomotor center would then be chiefly traceable not to a local fatigue, but to Howell's two secondary factors, diminution in cortical irritability and withdrawal of stimuli. The divergence of the intensity curve of sleep and the plethysmographic curve is as readily explainable from this standpoint as from Howell's. The long continuance of sleep at low intensity would be due to the need for extensive storing of material within the cell to meet the demands of the day period, while the character of the plethysmographic curve would be accounted for by the continuance of the bodily conditions of rest, together with the low state of cortical activity and the lack of external stimuli.

From the time of Durham, circulation theories have taken as their foundation cerebral anæmia. There is another class of theories, however, which, while recognizing the force of the new experiments, has managed to save some of the elements of the older congestion theory. Sergouyef,[3] influenced largely by the definition of sleep as a state in which active nutrition is maintained without diminution, accepted anæmia of the cortex, but believed in hyperæmia of the portions at the base of the brain. His position is somewhat strengthened by Brown-Sequard, who reports observations of hyperæmia at the base of the brain in many animals during sleep, and has also shown that congestion can be produced in the same way as cerebral anæmia by bilateral section of the two great sympathetics. De Boeck and Verhoogen have more recently attempted a somewhat similar theory. According to them, the resistance to the flow of blood in the arteries supplying the cortex is greater than in those supplying the base of the brain, since they are smaller, longer and more tortuous, while the other arteries, shorter and more numerous, leave the Circle of Willis

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[1] Verworn, p. 572.
[2] ...h: p. 109.
[3] Berger and Loewy.

at right angles. For this reason, when the arterial pressure is lowered, anæmia in the cortex is relatively greater than in the basal ganglia. This, as Howell points out,[1] would serve to explain how functional activity of the cortex could be suspended upon moderate fall of pressure, while that of the lower centers remains. There is, however, danger in over-estimating this difference, for we have the best of reasons for believing that the activities of nutrition are not absolutely heightened, but only relatively, in proportion to tissue waste. We have shown above that the loss of tone in the nervous system is general. Owing to his peculiar mechanics of circulation, Cappie, originally a full fledged congestionist, is still able to maintain venous pressure upon the brain substance as the immediate cause of sleep.[2] He accepts the Monro-Kellie doctrine that the total quantity of blood in the cranium, since it is a closed cavity, is invariable, and that only changes in its distribution can occur.[3] Hence, arterial and capillary anæmia is to be correlated with venous congestion. Granting that the Monro-Kellie hypothesis is true, still the compression of the brain substance could not occur: for under physiological conditions the intracranial pressure (the pressure of the brain upon the cranium) and the cerebral venous pressure are the same. The brain substance transmits pressure. It, itself, is incompressible.[4]

Now that we have examined the most typical, we are ready for a summary of the principal evidence upon which the vasomotor theories rest, and a consideration of the adequacy of any such theory to cover the facts. (1) Observations made upon the condition of the brain in cases of fractured skull, show a decrease in brain volume during sleep, and mental inactivity, an increase during periods of activity and excitement. This has been confirmed by experiments with the manometer. (2) Observations upon the condition of the cerebral blood vessels, after artificially exposing with all due caution portions of the brain surface, have uniformly shown an anæmia in arteries and capillaries. (3) Experiments in carotid compression, when not carried beyond certain limits, have produced states most similar to sleep, while jugular compression has resulted in a comatose state, utterly dissimilar. (4) In cases of fracture at the base of the skull or of traumatic injury to the cribiform plate of the ethnoid bone, permitting the escape

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[1] Howell: 1897, p. 340.

[2] For Cappie's works, see Bibliog.

[3] Hill, 1896, p. 30, without asserting absolute invariability, replies to two arguments that have commonly been urged against the Monroe-Kellie theory.

[4] Demonstrated by Grashey. Hill: *op. cit.*, p. 2.

of the cerebro-spinal fluid,[1] the escape is found to be either absent or diminished during sleep and mental quiescence. (5) The retina is genetically an outgrowth of the forebrain. An examination of the retinal vessels by the ophthalmoscope shows them to be in a contracted state during sleep, while awakening is accompanied by dilatation.[2] (6) By various experiments, it has been shown that many of these areas, whose blood supply stands in reciprocal relations to the brain, are congested during sleep, or that a derivation of blood to them produces somnolence. (7) The arterial pressure decreases during sleep. The pulse rate is slackened. The frequency and force of the heart beat are lowered. (8) One of the chief causes of insomnia is a disturbance of the vasomotor mechanism. It is a general law, which, of course, may be cut across by other special laws, that whatever tends to increase the cerebral circulation, increases cerebral activity and is hostile to sleep.[3]

These facts are all well attested and are sufficient to put beyond any reasonable doubt the anæmic condition of the cortex,[4] notwithstanding the immense complexity of conditions of cerebral circulation and our present ignorance concerning them. Many writers, like Vulpian or more recently Berger and Loewy, without committing themselves to congestion, have urged objections against cerebral anæmia. These objections are all founded upon insufficient observations or insufficient knowledge of the experimental work of others. No sleep theory that pretends to anything like completeness can afford to slur over these facts or attempt to pass them by without explanation. The great point of controversy, in the past, has been as to whether anæmia is the cause or the result of the physiological condition of the nervous system during sleep. This question is not answered by mere appeal to the fact as established by manometer, sphygmograph, and plethysmograph records, that vascular changes occur prior to the onset of sleep. So also do changes in respiration, and in muscular tone. A search for the cause of sleep has led in our own case, and we believe must necessarily lead, beyond the circulatory system and the particular nervous elements directly connected with it, to alterations occurring in the higher nervous centers,—the histological modifications of the cortex

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[illegible] ion, 1899.

[illegible] ents and observations upon insomnia, [illegible] law is founded upon a wide factual

[illegible] cerebral venous anæmia open. The ques- [illegible] the anæmia theories, for venous congestion, [illegible] regarded as a compensation for circulatory [illegible] of the older congestion theories as a cause

and the deeper lying chemical changes that occasion them. The shutting down of the circulation is only one in a cycle of events. It results from a temporary derangement of the nervous mechanism, and in turn adds still further to the disintegration. As to the importance of anæmia as a secondary factor in the causation of sleep in man, it is yet too early to make a just estimation. In this connection, it should be remembered that the absolute quantity of blood in the brain and cord is unquestionably small: to judge from observations upon animals, it is not more than one-tenth of the entire blood in the body.[1] Such a statement, however, needs to be qualified by the consideration that it is only the cell-bodies which are well supplied with blood. We have also seen that the nerve cells are, in a certain measure, independent of the circulation. Whether or not vasomotor changes are an essential factor is a question to be left to comparative physiology.

II. The Chemical Theories.

The vasomotor theories, with which we have been dealing in the preceding paragraphs, were developed chiefly by English physiologists. Shortly after the important experiments of Durham and Hammond, researches in physiological chemistry reached a stage in development sufficient to serve as a basis for a new line of sleep theories. The principal exponents of these chemical theories are to be found among French and German writers. Naturally, their period of greatest influence did not come until after that of the anæmia theories. Largely as a matter of convenience in treatment, although not without some scientific justification, we shall divide the chemical theories into two groups: (1) the combustion theories; (2) the auto-intoxication theories.

(1). The Combustion Theories.

The common trait of the theories, which we shall treat under this rubric, is that they are all theories in terms of oxygen or carbonic acid gas. The most typical gives the name to the group. Historically, they belong to the earlier period.

In 1867, Pettenkoffer and Voit performed the classical experiments which resulted in the gaining of a new point of departure. These investigators found that the amount of oxygen absorbed during the night was greater than during the day, while the amount of carbonic acid gas eliminated was considerably less.[2] Sommer, following a year later and inter-

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[1] Donaldson: Am. Text Bk., p. 736.

[2] Serious doubts are thrown upon the validity of the results of Pettenkoffer and Voit, for their tables show not only that the absorption of oxygen during sleep is greater than the elimination of carbonic

preting these results, attempts to show that sleep results from the exhaustion of reserve oxygen, which has been stored up in the cells and blood during the night for the activities of the day.

Pflüger (1875) elaborates the theory still further, and lays the greatest stress upon a gaseous exchange.[1] The stored up intramolecular oxygen is replaced by carbonic acid gas. When the replacement is complete, all the activity ceases. The intramolecular conditions which accompany the formation of carbonic acid gas are such that the atoms of its molecules at the moment of its production are in a state of most violent oscillation, just as in explosion. These explosions, which are constantly taking place throughout life, excite vibrations in the surrounding atoms, and radiate far and wide along the lines of connection of the nervous system and its annexes, causing the explosion of other cells. The molecular changes are attended by a consumption of oxygen greater than living molecules can take up at the same time. Hence, the amount of carbonic acid gas produced must necessarily diminish. Now the cortex is probably the seat of more active chemical processes than any other portion of the body, and therefore requires a large oxygen supply. As the production of carbonic acid gas diminishes, the explosions become less numerous and the condition of relative cerebral inactivity—sleep—results. The analogy of the vibrations of the strings of the harp, which continue vibrating for a long period after the blow which set them in motion, gives us a clue for the explanation of the long duration of sleep after the reabsorption of oxygen in the brain has commenced. The loss of irritability during sleep is due to the exhausted condition of the nerves and the greater cohesion of cerebral molecules, caused by diminution of the total heat produced by chemical processes in the brain. Sleep or waking depends primarily not upon the amount of potential energy in the brain, but on the amount of *vis viva* of the intramolec- movements.

ry of Pflüger is by far the most completely developed roup. Various other writers have emphasized the by carbonic acid gas in the causation of sleep, some o it a positive sedative effect;[2] but the importance

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at it is greater than the absorption of oxygen during iod. The safest view is that during sleep as during re is a diminution in both the production of carbonic e absorption of oxygen, but that the diminution in the arbonic acid gas is relatively greater. See Saint-Mar- p. 1124 ff. Experiments of Quinquand and Zunts. Am. Manacéïne, pp. 8, 171.
ly from Lancet.
Vol. XCVIII, 1868, pp. 213 ff; Wurtz.

of carbonic acid gas as a positive factor has been left in the background by the line of development which the auto-intoxication theories have taken.

There is abundant evidence to prove the presence of a reserve supply of oxygen in the cells. An amœba continues movement in an atmosphere of hydrogen for twenty-four minutes; an excised muscle remains irritable for even a longer period.[1] In both cases after complete exhaustion oxygen is necessary to restore vitality.

The question of whether or not the cortex is the seat of very active combustion cannot, at present, be said to be definitely settled. Results from Mosso's[2] temperature experiments and Hill and Nabarro's[3] experiments on gaseous exchange in muscles and brain are contradictory. Pflüger is, without doubt, right in attributing to the cells of the nervous system the greatest sensitivity to the lack of oxygen. This would explain the quick and violent death of the higher vertebrates from asphyxia, in comparison with the slower death of lower organisms, since in them the nervous system has gained a more complete control of the respiratory and cardiac muscles. The other cells, in particular the ciliary cells, continue to function long after the nerve cells have ceased.[4] Speck (1892) has performed an important experiment, directly to the point. He inhaled air from a vessel, counting at the same time. The air lost its oxygen. When the oxygen of the inhaled air fell to eight per cent. of an atmosphere in pressure, the counting stopped and unconsciousness resulted, although the other functions of the body showed no alteration. Recent investigations have brought out fundamental facts concerning tissue oxidation, and have exhibited at once the great complexity of the chemical processes occurring in the cell and our immense ignorance of them. "The amount of oxidation is not increased in an atmosphere of pure oxygen nor within wide limits is it affected by variations in atmospheric pressure."[5] A certain amount only of oxygen is needed, and this amount is determined by the amount of metabolism, not the reverse as was formerly supposed.[6] As to the cause of cell decomposition, we have evidence that certain bacteria, chiefly in the intestinal tract, cause putrefaction, but as to the main cause we can only say that it is internal, in the cell itself, and resembles fermentation. The function of oxygen appears, then,

[1] Verworn: p. 263.

[2] Mosso, 1894, finds the temperature of the brain frequently higher than that of the aortic blood.

[3] Hill: 1896, pp. 152 ff.; Hill and Nabarro, 1895, find combustion of muscles very much greater than of brain.

[4] Verworn: *loc. cit.*

[5] Lusk: Am. Text Bk., p. 945.

[6] See Loeb, 1899, p. 165.

tion of organic substances during muscular activity. This might be used to explain the disturbance of sleep, following excessive fatigue, since the organic narcotic substances would be decreased through oxidation, while the mineral convulsive substances would not be affected. Investigations upon the toxicity of the blood have even a more direct bearing on sleep problems than those upon urine. Bouchard's estimate from his own experiments is that one kilogram of blood can kill between 1,250-3,000 grams of living tissue.[1] This, he admits, is perhaps too high an estimate. However, death in an animal results from increase in the amount of poison in the blood to two and one-half times its normal quantity.

We have already pointed out the danger of interpreting a physiological by reference to a pathological condition. Arguments from the effects of drugs and narcotics are precarious, so also arguments from Bouchard's experiments, for, in all, urine was injected until death of the animal followed. The mental state produced prior to death was that of stupor, not sleep. Yet, inasmuch as toxic substances are shown to result from functional activity, there is a strong probability that under normal bodily conditions their accumulation plays a part in the causation of sleep. They may act physically, *e. g.*, by mere clogging, as well as chemically.[2] To assume that auto-intoxication is the sole cause of sleep, or to attribute the narcotic effect to any one group of decomposition products, is to dogmatize. "We really know only that living substance is continually undergoing decomposition, for this is apparent from the output of decomposition products. But as to the path from the complex proteid compounds to the end products, as to the special chemical transformations that take place, our knowledge is very incomplete, since, as yet, the composition of proteids is known very slightly."[3] On the auto-intoxication theory, notwithstanding Errera's attempt, it is extremely difficult to explain the long duration of sleep.[4] An insufficient supply of nutrition, in the end, leads to the same results as an accumulation of decomposition products. In all normal fatigue curves the loss of power is at first rapid and then slow.[5] These facts suggest that at the beginning of sleep the more active factor is an auto-intoxication and that, when the oxidation process of the fatiguing substances is completed, the intensity of sleep sinks and remains for so long a period at low level, in order to allow the cells to recover from the effects of exhaustion of the day and to lay in a store of new materials. Thus, exhaustion as well as an accumulation of fatigue products would precede sleep. Both would be causally connected with its onset. The exact relation between the two, of

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[1] Bouchard: pp. 69 ff.
[2] Loeb: p. 165, 1899.
[3] Verworn: p. 161.
[4] *Cf.* Howell, p. 338.
[5] Donaldson: 1897, p. 312; p. 322.

within the last decade has opened up a new and attractive field to science. The outlines of the nerve-cell and its processes, brought out with clearness, show the neurocyte[1] to be a structural unit. With the recognition of the morphological independence of the nervous elements, one of the main problems for the nerve histologist is to account for physiological interdependence. Hence, many painstaking investigations have been made upon the difference in condition of the neurocyte during functional activity and during repose. These investigations have a direct bearing upon the problem of sleep, and have resulted in the formulation of numerous sleep theories.

The first of these theories to deserve attention is that of Rabl Rückardt (1890). The conception that underlies his theory is that the neurocytes possess a kind of amœboid movement, which allows them to make or break contact by means of a retraction or expansion of the prolongations of their neuro-dendrons. Sleep and hypnosis are the psychological correlates of a partial paralysis of these amœboid prolongations, resulting in an isolation of nervous elements. Lepine (1894), in attempting an explanation of anæsthesia and motor paralysis in hysteria, is led to a somewhat similar theory of sleep. He confines the amœboid movement to the extremities of the neurodendrons. Querton may also be quoted in support. Duval's theory (1895) is by far the most widely known and elaborated of any of these theories. Wiedersheim's alleged direct observations of amœboid movement in the neurocytes of the superior ganglion of Leptodera hyalina have largely influenced him towards amœboidism. He does not regard actual contact as essential for transmission of nervous impulse, but only a certain degree of contiguity. During sleep, this degree of contiguity is lost by a retraction of the ramifications of the cell-processes. He explains the functional activity of the lower centers during sleep, by the fact that currents of contact are set up among the amœboid prolongations by chemical processes started by decomposition products (chemiotropism). Chemiotropism is not intense enough to allow the impulse to reach the cortex. When the necessary degree of chemiotropism is reached and the currents of contact have become sufficiently extensive, awakening results.[2]

There remain but two other histological theories to be considered. Since they are both largely the result of negative criticism, it might be well here to attempt a brief summary of the most important facts discovered concerning the neurocyte in functional activity, quiescence, and fatigue.

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[1] Terminology of Fish.
[2] Pupin (1896) strongly defends Duval.

1. As to cell-body.

Flesch (1884) noted the difference in the reaction of cells to staining reagents after activity, and distinguished cells on this basis as chromophile and chromophobe. Vas (1892) experimented upon the cervical ganglion, and confirms Flesch. Vas found that the immediate result of activity was a swelling of the cell. Mann (1894) extended the observations to motor cells of the cord and sensory cells of the retina of the dog. He concludes that during rest there is a storing of several chromatic substances, which are used up in activity. In the cells observed there was in normal activity an increase in the size of cell, nuclei and nucleoli. Fatigue was characterized by a shrinking of the nucleus and probably of the cell and by the formation of a different chromatic substance. Lugaro (1895) in the main confirms Mann. The decrease in volume has been put beyond doubt by the thoroughgoing investigations of Hodge (1892-94). He found the most clearly marked differences in the nuclei, the decrease depending upon the length of time of stimulation. The outlines of the cell and nucleus became irregular, and vacuolation was present. Hodge also demonstrated the presence of fatigued cells in various animals after a day of normal activity. Further experiments made by the same investigator upon the effects of old age showed likewise a decrease in the volume of the cells and nuclei and an increase in pigmentation.[1] Heger (1899) found a shrinking of cell-body in ether, chloroform, and morphine narcosis.

2. As to cell processes and appendages (gemmulæ).

Heger has shown that in animals decapitated in the waking state, under normal conditions, the neurocyte possesses numerous dendrites of uniform calibre throughout their whole length, provided with many gemmulæ. The appearance differs somewhat from one species to another, but remains the same in animals of the same species. Under the action of chloroform, morphine, alcohol, and prolonged electric stimulation, Demoor (1899) noted the loss of gemmulæ and the formation of moniliform varicosities, which disappeared on return to normal state. Experiments of Stefanowska, Querton and Heger, confirm the observation. The results of Lugaro's experiments in the main agree.[2] He is convinced from his own and Ramon y Cajal's experiments that many of the varicosities observed are attributable to defective technique. The formation of these varicosities he regards as occurring independently of the retraction of gemmulæ, and as an indication of fatigue. He found little alteration in the condition of the trunks and larger branches. Berkeley[3] has shown that the gemmulæ are irregular and absent in certain mental disorders. After numerous experiments upon normal, over-excited, hibernating, narcotized animals, and animals killed by cold, Heger[4] concludes that variability is an important property of the neurocyte, and that these variations can occur in the cell-body, the prolongations, or the gemmulæ, simultaneously or independently. [illegible][5] has extended these investigations to normal fatigue, with [illegible] results. During the growth of the brain, while medullation [illegible] has not taken place extensively in the cortex, [illegible] cells to gain their position in the adult structure

[illegible] Physiol., 1894.

[illegible]ner, Die nervösen Centralorgane, Leipzig, 1888, pp.

[illegible] Jour. of Physiol., II, No. 3, p. 13.

doubtless can occur. Notwithstanding the seeming positiveness of these results, the question as to whether or not any movement occurs in the developed neurocyte at all comparable to the movements of the amœba or leucocyte must be regarded as still open, so long as Kölliker and Ramon y Cajal refuse to give their assent.

Ramon y Cajal's refusal to accept amœboidism is due to his belief in the great mobility of the neuroglia cells, in which the neurocytes are bedded for support. This forms a starting point for a theory of sleep.[1] The neuroglia cell by an intervention of its pseudopodia between the neurocytes, he supposes, can block or stop the passage of nervous impulses, so that various degrees of nervous coherence are possible. Experiments have confirmed the mobility of the neuroglia cells.

Lugaro (1898), accepting the plasticity of the gemmulæ, presents an entirely original theory. According to him, in normal mental activity only a few of the possible connections between neurocytes can at a given time come into play. It is necessary that the rest be interrupted by a retraction of gemmulæ in order to impede access of other stimuli, which would be able to deviate or suppress the one that is being elaborated in the cell. Strong stimuli or those of immediate importance to the well-being of the organism can, of course, break through. With the exhaustion of the contractility of the gemmulæ due to fatigue (auto-intoxication in particular), greater torpor of their movements results. Consequently, contacts are multiplied until the nervous impulses become more and more diffused throughout the cortex and individual processes are lost in the maze. The same condition can be reached through a lack of stimuli. Lugaro repeatedly appeals to psychology to support his theory, particularly to the phenomenon of attention. Wundt's[2] is by far the most satisfactory psychophysical theory of attention. It possesses innumerable advantages over Lugaro's. As an explanation of the cortical state during sleep and dreams, Lugaro's theory is seen at its best. But dreams are only one among many abnormal, or better non-normal mental states, which are characterized by a disaggregation of the normal consciousness into smaller and more elementary groups.[3] Dreams give the type of the greatest dissociation. If psychological facts are to be urged in behalf of histological theories, their weight would seem to be in favor of that of Duval or Ramon y Cajal. A compromise between Duval's and Lugaro's theory is not, however, an impossibility.

It is hardly within the province of a layman to attempt de-

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[1] Ramon y Cajal: 1895.

[2] Wundt: 1887, Bd. I, pp. 282 ff; G. E. Müller's theory is also well known, Zur Theorie der sinnlichen Aufmerksamkeit, 1873.

[3] *Cf.* Janet, L'Automatisme psychologique, 1894, pp. 484 ff.

tailed criticism of histological theories. From a glance at those presented, it will be seen that three lines of attack, and the only three lines possible, have been taken: (1) a dissociation of nervous elements, caused by an amœboid movement of the attachments of the neurocyte; (2) a dissociation of nervous elements, caused by an interposition of the pseudopodia of other cells; (3) a diffuse connection of nervous elements caused by torpor of movement of the attachments of the neurocyte. The decision between these three must be left to future investigations of the histologist. It is no reflection on the importance of such research to admit that the histological theories can only be theories of the changes occurring in the nervous mechanism. The causes of its derangement will still have to be sought.

IV. The Evolutionary Standpoint.

In our consideration of the various lines of sleep theories we have found that no one of them alone is adequate as a complete explanation. The vasomotor, the chemical, the histological theories are all capable of being based upon a wide range of facts. Their several claims cannot be ignored, but must be reconciled. In the immense complexity of the human organism, the primary factors of sleep are so overlaid and obscured by secondary ones that it is next to impossible to trace them out. Hence the necessity, if profitable work is to be done in the future by the physiologist, for a broader point of view. The sleep problem must be attacked genetically. It is true that comparative physiology is still in its infancy, that at present few facts are known concerning sleep phenomena except in the higher vertebrates. To attempt any elaborate theorizing would be useless. There are, however, enough facts to point unequivocally to the conclusion that sleep is the product of evolution, and to indicate the main lines which any evolutionary theory will have to follow. Three questions, which cannot be kept wholly separate, naturally arise.

1. What is fundamental in the phenomena?
 How has selection operated upon sleep? How have the ıdary factors crept in, and what is their relative impor- ?
 How shall we define sleep? What are the limits of the m?

ve and Aikins (1895) have made a careful study of the e of a protozoan, with special reference to the rhythm nd activity. Observations were recorded upon a vorti- · a period of twenty-one hours, without interruption. other experiments were afterwards made. Automatic ɔns of cilia were continuous, those of the vesicle

nearly so, while contractions of the stalk were irregular and occurred usually upon presence of stimuli. The conclusion to which the writers are led is that vorticellæ neither rest nor sleep. Hodge assumes that the unicells possess a rudimentary form of consciousness. Whether or not the lower organisms do now or have once possessed consciousness, which has since dropped out, is a disputed question. It would be unwise, before there is a more general consensus of opinion among authorities, to encumber a sleep theory at the outset by definite commitment to any theory of the origin of consciousness. These experiments with the vorticellæ are of great value, since they show clearly, what might be expected *a priori*, that in a simple organism with adequate provision for food supply and removal of waste products continuous response to stimuli without diminution of irritability is possible. There is no reason to hold that fatigue is a general phenomenon common to all life.

For the sake of making the problem of the fundamental in sleep more definite, let us try to picture what would be the mental state of the simplest organism capable of serving as the support of consciousness, and living under conditions so favorable that fatigue could not occur. This primitive consciousness we may, without violence, suppose to be a motor consciousness. If we exclude the action of hostile agencies in the environment, the only occasion for the cessation of consciousness would be the lack of adequate stimuli. A state of full consciousness[1] would exist in the presence of an adequate stimulus, and on its absence a mental blank or a vague organic sensation. At irregular intervals states of consciousness and unconsciousness would succeed each other. The ultimate reason for the presence of the latter is not to be sought outside of the organism in the withdrawal of stimuli, for stimuli are always present, but in the internal conditions which render the organism unable to receive or respond. The chemical composition of the cells is relatively too simple, the nervous elements too poorly organized, or the vascular system, if blood circulation be present, defective. The operation of these causes is not confined to the lower animals. Strümpell[2] reports a case of general anæsthesia in a boy of sixteen, who was left with the sensibility of only one ear and one eye unimpaired. Sleep could be produced at any time by the closure of the eyelid and the stoppage of the ear. Through an inherent limitation of capacity, other than that manifested in or brought about by fatigue, the physiological processes underlying consciousness may sink to so low a level of intensity and extensity that

[1] Idea or sensation given in a state of attention and felt. *Cf.* Titchener, Outline of Psychology, New York, 1899, pp. 249 ff.

[2] Strümpell: Pflüger's Archiv, Bd. XV, p. 573; Nature, Dec. 13, 1877 (tr.).

sleep results. This inherent limitation of capacity is to be conceived of as due to a state of development inadequate to meet the demands of continuous consciousness. We shall include all the foregoing causes as well as those that spring from degeneration under the rubric Lack of Development.

The factor, Fatigue, now demands our attention. Even without the presence of consciousness, the development of the multicellular organism must have continued to the point where a fatigue of nervous elements would occur, for, with increasing complexity of structure and function, the utility of bringing the cells and groups of cells into more intimate relations with each other, in order to gain unified co-operation and advantageous adaptation to environment, becomes apparent. The performance of this function calls for a developed nervous system. The ascendency of nervous tissue over all other tissues is to be correlated with an increase in chemical complexity of the cell and an increased metabolism. For its demand upon food supply and for removal of waste, the nerve cell is left dependent upon the alimentary tissues and the circulatory system. Fatigue, implying among other things a diminution of irritability, thus inevitably arises in the course of development. If such a condition would be brought about without the presence of consciousness, its onset is made all the more certain and rapid by the possession of mentality, for consciousness once present has a survival value and adds greatly to the demands made upon the organism. Were it not for fatigue, the development of the nervous system might be carried to such a point that consciousness could be present continuously. Fatigue is the one great factor that forever makes sleep a vital necessity. Arising in the course of development, it ends by limiting the possibilities of development. Operating as a cause it limits further capacity for function, though it, itself, results from a limitation of capacity. As such it can be placed along with the other causes under the rubric Lack of Development. But Fatigue is a positive, well defined, wide spread condition arising only after exercise of function. It can be clearly distinguished from the other conditions inhering in the organism that limit capacity; and since the distinction is an important one and we have no other term to use, we shall confine the term Lack of Development to those causes other than fatigue.

Sleep, then, results from the limited capacity of the organism to receive and respond to stimuli, either through Fatigue or through Lack of Development. Both factors are internal. The relation of each to function can be traced along chemical, histological and vasomotor lines. What is their relative importance in the causation of sleep? In man, fatigue by itself can occasion sleep, while a reduction of external stimuli to the

minimum is not sufficient to cause sleep in an individual of highly organized and well nourished brain without the presence of fatigue; for central excitations, along with the remaining peripheral, would maintain an adequate support for consciousness. In animals low down in the scale, cessation of consciousness can occur without the presence of fatigue, by the mere withdrawal of adequate stimuli. Thus at one extreme of the series fatigue alone can cause sleep, at the other lack of development. Between the extremes the two factors do not stand in relations of reciprocal importance, for in most instances the more poorly organized and developed the nervous system, the more easily is it fatigued. This is well illustrated by the ease with which children, savages, and the insane are fatigued by work that requires mental concentration, and their great need for sleep in comparison with the normal adult. On the other hand, the short sleep periods of great men have often been remarked.

We are now ready for our second question as to the operation of selection upon sleep and the rise of the secondary factors. In every organism at all developed, we find firmly rooted habits of activity and repose. These habits are rhythmic, and, if not ultimately caused, have been powerfully influenced by rhythmic changes in environment. Even without the presence of fatigue, such changes would have been capable of establishing rhythmic periods of greater and lesser activity; but, fatigue being an inevitable product of evolution, it becomes all the more imperative that rest periods be grouped. It is an obvious economy to the organism that the rest periods should correspond to periods of lessened adequate stimuli. A very profitable field is open to the physiologist in tracing out this correlation. Loeb has already shown the importance of light to animal life. Heliotropism,[1] quite comparable to that in plants, is observable in the animal kingdom. The influence of light upon sleep habits[2] is clearly brought out by the fact that animals which depend chiefly upon smell and hearing are much less regular than those with largely developed vision, such for instance as birds. The former can sleep quite independently of the time of day, while sleep in the latter corresponds closely to the rhythm of daylight and darkness, even varying with the changes of season. Lack of data compels us to leave the most fascinating problem of sleep rhythms in this fragmentary way.

With the development of the organism and the appearance of new adaptations, an opportunity for the operation of new internal factors is afforded. The most important of these is the blood supply. That the circulation is not fundamental can

[1] Loeb: 1890.
[2] Donaldson: 1897, p. 297.

be seen from the fact that in insects and plants, devoid of a vascular system, well defined periods of rest and activity occur.[1] When the organs of blood circulation appear, according to the principle of utility their development is accompanied by an increased control of the nerve cells over the supply. A complex and nicely adjusted vasomotor mechanism is the result. The rhythm of this system is derived from the rhythm of the vasomotor nerve cells. Their rhythm in turn is not independent of, but directly determined by, the primary rhythm in the central nervous system, so that while the higher centers are made dependent upon the circulation for food and removal of waste, they are dependent upon it as a master upon the performance of the work of a servant, not as a servant upon the bounty of a master. The precise work that the circulation performs in bringing about the condition of sleep in man is probably rightly estimated by Howell,[2] who urges that diminution of blood supply can best explain the sudden and comparatively simultaneous onset of sleep.

High up in the animal series, where consciousness plays an important role, another factor enters,—conscious adaptation to the conditions most favorable to sleep. A glance at the arrangements of modern sleeping rooms, the preparations usually made before retiring, and the bodily position assumed for the night's repose, will show that they have as their objects the reduction of external stimuli to a minimum and the derivation of blood from the head. Adaptations originally conscious may, of course, become reflex and appear later as inherited reflexes.[3]

There remains but one other factor to be considered. The psychophysical phenomenon of attention cannot be overlooked.[4] The hypnotist in artificially producing sleep resorts to a sudden stimulus or repetition of monotonous stimulus, frequently a command or suggestion, capable of holding the attention. A complete sleep theory should seek to trace the factors exhibited in the artificial state as they occur in the natural state, and to show their relative importance to sleep phenomena in general. Hypnotic sleep is most easily explained physiologically by inhibition. Certain processes on their arousal inhibit other processes in the cortex, reducing them below the level of extensity required for consciousness. It is possible that fatigue, produced by excessive activity of portions of the cortex,

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[1] Loeb: 1898.

[2] Howell: 1897.

[3] In this connection Goltz' experiments are of interest. His decerebrized dog "slept" like any normal dog. Many of the habitual positions in sleep might well be purely reflex; see Goltz, Der Hund ohne Grosshirn, Pflüger's Archiv, Bd. LI, 1892.

[4] *Cf.* Külpe, Outlines of Psychology (Tr.), 1895, pp. 452 ff.

may also contribute powerfully to the result. The influence of repetition of monotonous stimuli upon sleep has often been attributed wholly to fatigue, but in our judgment it more properly falls under the same general explanation as hypnotic sleep. We must deny to these causes fundamental importance to the production of sleep, for their operation is accidental and without universal significance. The nervous mechanism is not so poorly constructed that under normal circumstances it is obliged to suspend its chief function from an antagonism of parts.

In a work that is admirable for its array of facts, Madame Manacéïne has attempted to state a theory of sleep in the brief formula: "Sleep is the resting period of Consciousness."[1] The phrase is not intended as a metaphor, but is put forward seriously as an explanation and continually used as such. There is probably no field in science, where the loose use of terms is more harmful than in psychophysics. The formula as it stands is meaningless nonsense. Consciousness, as such, has no more need for rest than it has for nutrition. It is true that the sleep problem has a psychological as well as a physiological side. Investigations of hypnagogic states and of dreams are to be correlated with investigations of the condition of the brain. Between the two series, no causal relation can be assumed. But just as the *raison d'être* of death is to be sought in a breaking down of the physical organism, so the *raison d'être* of sleep is to be sought in a temporary derangement of the nervous system. Manacéïne's formula, when put into scientific language and properly interpreted, is a profitable conception. Sleep is the resting period of the *support* of consciousness. This differentiates the phenomenon of sleep from all other rhythms, and gives the sleep problem a definite place under the more general problem of rhythms in the nervous system. The term *sleep* is then reserved for that particular phase of the rhythm of the cortical or nerve cells which has as its psychological accompaniment a cessation of consciousness. It is well that such a differentiation should be sharply made. The nyctitropic movements in plants, the rhythm of activity and repose in a decerebrized dog or (if consciousness be denied to them) in the invertebrates, are only comparable to sleep on its physiological side. Without the psychological accompaniment, the term is no more applicable here than it would be to all periods of loss of power in the diurnal fatigue rhythm.[2] A word perhaps needs to be said concerning the various states that resemble sleep. In some cases it may be difficult to determine; but as the conditions of sleep become more fully known, it will become

[1] Manacéïne: pp. 59 ff.
[2] For curve of diurnal rhythm, see Lombard, Jour. of Physiol., 1892; Ostanikow and Gran, Neurolog. Centralbl., 1893.

easier to distinguish between the normal and the abnormal. Little light upon the sleep problem can be expected from a study of abnormal states. Such a study demands first a thorough understanding of the normal, and is rather a field for the application of general principles already discovered to special problems, than a source of new knowledge.

The three questions raised at the outset have been but meagerly and imperfectly answered. It is enough to have pointed out some of the difficulties and the possibilities that lie before an evolutionary theory of sleep.[1]

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Manacéïne at the end of Chap. I has an excellent bibliography. She also gives a short account of many sleep theories (pp. 40 ff), although with little attempt at criticism. I take pleasure in acknowledging my indebtedness to her work for much of the purely historical part of this article.

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A 'COLOR ILLUSION.'[1]

By M. F. McClure, B. S.

In "Studies from the Yale Psychological Laboratory," Volume VI, 1898, there is an article entitled "A Color Illusion" by Professor George Trumbull Ladd. In it reference is made to a colored diagram, called an "example of Stilling's Charts," used for testing color blindness. The chart consists of a pale green background, 36 mm. by 44 mm., which is divided into squares of 1.8 mm., by white lines 0.4 mm. in width. On this background a red letter E, 21 mm. by 34 mm. is constructed out of similar red squares. It was noticed that when this figure was observed with a fixed gaze for a few seconds, some or all of the squares disappeared, and were replaced by green squares like those of the background.

When it was found that the illusion was not dependent upon the white division lines, a series of experiments was devised by Dr. E. W. Scripture to test the effects of varying the color of the background—or "substituting color"—while retaining the same red as the "disappearing color," without dividing either background or strip into squares. A set of Milton-Bradley colored papers was used, and out of these, sheets, 20 cm. by 30 cm., were cut for backgrounds, while small strips, 1 cm. by 20 cm., were cut, ready to lay on the backgrounds. To make the experiment, a background of a desired color was fastened to a board by tacks, and a colored strip was fixed on it by a pin; the whole was then observed at a distance of about 3 m. Although the results varied somewhat with different observers, yet "they remained fairly constant of the same order." 'he results obtained by a standard red strip, fixated on various ckgrounds, may be divided, says the author, into two classes. h certain backgrounds—green, blue-green, violet, blue and ck—the illusion of disappearance and substitution takes e quickly and suddenly. With other backgrounds—yellow, e, light gray, white, light blue, light green and a light violet—the substitution takes place with great difficulty, at all. If the same experiment is made with an orange the illusion comes with green, dark violet, dark blue or blackgrounds, only after persistent trying. On the red

[1] the Psychological Laboratory of Cornell University.

strip the color darkens, but on the orange strip it lightens, and the background color seems to encroach on the strip from both sides until (where the strip does not disappear entirely) it is but a narrow "line of sunlight."

By way of general explanation, fatigue, in the sense of the Young-Helmholtz theory, is suggested. The colored strip is said to fatigue the eye and thus to create a temporary blind spot, which is filled in by the color of the background as the permanent blind spot is filled from surrounding retinal areas. The explanation is admitted to be unsatisfactory, for (1) dark strips seldom disappear on light grounds, and (2) orange grew brighter and lighter, instead of darker, before disappearing.

Aside from the general difficulties which the principle of fatigue or exhaustion encounters (the rise of negative after-images after a very short exposure, while the eye is, nevertheless, able to function throughout the day), there are here two special difficulties. (1) Why should a limited retinal area succumb while other areas, which are similarly exposed to stimulation, are unaffected? In the second place, (2) fatigue, as generally conceived, does not produce an entire absence of visual sensations, but only a change. Exhaustion to red, for example, produces some other color than red, depending on conditions of stimulation. The exhaustion of the "red-fibre" does not straightway throw the visual apparatus out of function; it only changes the reaction of the apparatus.

Since the explanation is avowedly inadequate, and since the phenomena described have considerable interest in connection with theories of color-vision, at large, it has seemed worth while to repeat the Yale experiments with some modifications.

The experiments which are described below were carried out in the Cornell Laboratory during the academic year 1899-1900.

Sheets of colored paper (Milton-Bradley), 10 cm. by 15 cm., were cut out for backgrounds, and strips, 0.5 cm. by 10 cm., were cut out to be placed upon these backgrounds. A pin with a small, round, black head fastened the strip vertically to the middle of the background, and also fastened the background to a black upright screen, which was placed 1.5 m. from the observer. An uniform light fell on the strip, background and screen from behind the observer, so that no shadows or reflections were produced. A series of eighteen colors were used as backgrounds, while only the six 'standard' colors were used for strips. After a preparatory "Ready," the signal "Now" was given, a stop-watch was started, and the observer fixated the head of the pin. If the strip disappeared, and complete substitution took place, the observer indicated the fact, and the time of disappearance was noted. If it did not disappear, the fixation was continued for two and a half minutes. The intro-

spection was then written, and the eyes were rested until all after-images had disappeared, before proceeding with the next combination; the time allowed for rest being at least three and a half minutes. The colors used were:

Violet red (V. R.). Rather dull and dark.
Red (R.). Dark and saturated.
Orange red (O. R.). Vivid, brighter than R., saturated.
Red orange (R. O.). Brighter than red, very saturated.
Orange (O.). Very bright and vivid, strong.
Yellow orange (Y. O.). Bright, unsaturated.
Orange yellow (O. Y.). Bright, darker than yellow, unsaturated.
Yellow (Y.). Bright, very little saturated.
Green yellow (G. Y.). Vivid, bright, thin.
Yellow green (Y. G.). Bright, well saturated.
Green (G.). Moderately bright, not very saturated.
Blue green (B. G.). Bright, not very saturated.
Green blue (G. B.). Rather dark, not very saturated.
Blue (B.). Well saturated, darker than green blue.
Violet blue (V. B.). Dark, well saturated.
Blue violet (B. V.). Dark, moderately saturated.
Violet (V.). Rather light, not highly saturated.
Red violet (R. V.). Rather light, not very saturated.

The observers were Dr. Lane (L.), Miss Winger (W.), Miss L. Hempstead (H.), and the writer (M.), all students in the Psychological Department.

The first fact investigated was the disappearance of the strip. Out of 408 tests—each strip with all the different backgrounds repeated with the four observers (6x17x4)—there were 93 'disappearances.' Of these, 37 were reported by H, and the other 56 were distributed almost equally among the other observers (19, 20, 17). The number of disappearances of the strips, running through the spectrum from red to violet, was as follows: 14, 18, 8, 13, 23, 17; blue disappearing most often and yellow least often. There is a good deal of variability in the backgrounds upon which the strips were lost. Only once did all four observers report a disappearance with the same combination of strip and background. This was with *B.* on *V. B.* There
re 10 concurrent disappearances with 3 observers: *V.* on *G.*
?. *V.* and *R. V.*; *B.* on *V. R.*; *G.* on *R. O.*; *O.* on *R. O.*,
. and *G.*; *R.* on *V. R.* and *B. V.* Some disappearances
red with every background: *R.*, *O. Y.* and *Y.* gave the
(2 each), and *R. O.* the most (10). When one remem-
e heterogeneous nature of the papers, variations in bright-
olor tone and saturation, and mixture of pigments, one
dly wonder at the apparent confusion in the results. It
noting, however, that in the 11 concurrences which we
ntioned there exists in each case a likeness between the
the ground either in (1) color tone, (2) brightness,
of saturation or (4) in two or three of these moments
ie time.

Much more important than these numerical results (considering the unsatisfactory character of the estimate) is the introspective account of the experiments. Introspection brought out the following facts.

A. At the first glance the contrast, both in color and brightness, was greatest. This contrast was at times very striking.

B. Quite soon, however, the strip and ground began to lose saturation, and to approximate each other in brightness, until, in cases of complete disappearance, the brightness of the strip and of the ground were the same. Although both colors yielded to each other more or less, the strip yielded the most and was merged in the ground.

C. After the approximation in brightness, but before its disappearance, the strip was covered by a 'veil' of the background color, through which the color and form of the strip could be seen in a greater or less degree. Sometimes the color of the strip spread over the background to a small extent; the veiling of the strip occurred, however, in almost every case.

D. The strip then lost its identity, going entirely into the background which had diminished in saturation and in brightness of tone.

Beside this general course in the visual sensations, a number of special points were noted. (1) In 82 tests the strip either approximated the color of the background, or became merely a line of brightness with definite or indefinite outlines.

(2) In 44 tests the strip narrowed down to a small area directly around the pin head. At times, both color and form remained here; again, only color; and still again, just brightness remained.

(3) In 54 combinations the one end disappeared entirely, almost to the center. At times the one end would go and then the other, but never both at the same time, the upper end reappearing before the lower one went and *vice versa*.

(4) The background was surrounded at times by a halo of the complementary color.

(5) In 22 cases, the background or the strip lost in saturation, and approximated the other in brightness; it became a "peculiar, luminous gray;" and, finally, changing over, acquired either the color complementary to the original color of (a) the background or of (b) the strip, or (c) some other color.

Again, (6), in some instances, the strip and background simply lost saturation, and became grayer.

Conclusions.

Since the invocation of the principle of exhaustion or fatigue has been found inadequate, we propose to interpret the facts which have now been collected in the light of a rival theory

of visual sensations,—the theory of Hering. It is very evident that at least some of the phenomena which we have called attention to are intimately connected with Local Adaptation and Contrast. Suppose that we take Hering's account of these two groups of facts, as it is given in the "Zur Lehre vom Lichtsinne," and attempt to apply his explanations to the results before us.[1]

First in regard to our general results.

A. The increase in color and brightness differences at the very first is a matter of simultaneous contrast (pp. 42 and 129).[2] This is due to the indirect effects of stimulation.

B. The approximation in brightness and the decrease in saturation is due to *local adaptation*. As the effect of adaptation, all brightnesses tend toward a medium gray, and all colors tend toward their complementaries, passing through gray, the point of minimal saturation (pp. 131-134).

C. The veil of the background color which spreads over the strip is caused by simultaneous light induction.

This is, again, an illustration of the fact that the retina is an unit and functions as a whole. As a consequence, the effect of stimulation is not limited to the region directly affected but extends to neighboring portions of the organs (indirect stimulation). It is to be noted that the effect of simultaneous induction is reciprocal; the color of the strip spreads to the ground, and that of the ground to the strip (pp. 19, 29, 129).

D. This is simply a later stage in the processes already described. Adaptation continues to affect the colors of the ground and of the strip. There seems, however, to be a slower adaptation for the more extensive ground (we know that the color of a small patch is very unstable; *cf.* pp. 131-2) and hence a preponderance in the successive color induction from this to the strip. A very important point in this connection is the fact that the background is only *relatively* stable; it undergoes change as surely as does the smaller strip. This fact gives the key to the whole phenomenon. It seems to have been overlooked by Professor Ladd. To test the effect of steady fixation upon the background, the whole series of "substituting colors" was used without the strips, *i. e.*, they were simply fixated upon the black screen. Out of the 72 tests (18x4), 19 gave gray (total loss of saturation), 41 gave a partial loss of saturation, 8 gave the complementary color and 4 some other color. *In no single case did the ground retain its original quality.* The sudden "vanishing" of the strip, which occurs at times, is probably

[1] A good general account of the phenomena of Contrast and Adapta- ınd their explanation may be found in H. Ebbinghaus, *Grundzüge* ʾ*sychologie*, I, 1897, pp. 217-229, 245-263.

ue references are to the *Lichtsinn*.

due to fluctuation of attention at the point where differences of the strip and ground are almost eliminated.

The more special facts related above do not call for extended explanation. The cases in (1) are made intelligible by the smaller area of the strip as compared with the area of the background. Here extension is a factor in the determination of the qualitative effect, as in temperature it influences quantity (intensity). The instability of a small color-stimulus is more easily demonstrable if a liminal extent of color is taken. The exact value of the extensive attribute of visual sensations needs working out. The peculiarities of (2) and (3) are doubtless to be referred to attention to the black fixation point, and to differences in distribution of the visual substances. The halo in (4) is another instance of simultaneous induction (p. 129). We have already considered the conditions operating in (5). For the physiological processes in this case see pp. 126 ff.

It is worth noting that whenever the strip became complementarily colored it was a yellow or a violet strip,—a poorly saturated stimulus,—one, therefore, that stands near gray, and hence near its complementary. Where some color other than the complementary followed the loss of saturation, it was the color which would have been produced by the mixture of the strip color, or of its complementary, with the induced color from the ground; *B.* on *Y. O.* gave *G. Y.* three different times (*B.*+*Y. O.*=*G. Y.*),[1] and *V.* on *O. Y.* gave *Y.* (comp. of *V.*=*G. Y.*, *G. Y.*+*O. Y.*=*Y.*). Again, in the case of the grounds, it was the yellows and the violet which went over to the complementary color; both with the strip-background experiments and with the backgrounds by themselves. All these things we should expect to follow local adaptation and induction. Point (6) represents the first stage of adaptation.

Our observers noted the apparent lightening of the bright colors, orange, yellow and green, and darkening of the red and blue, with decreased saturation. A similar fact was mentioned in the Yale experiments. We are very strongly inclined to regard this as a misinterpretation of the facts. The absolute brightness of colors is difficult to determine. We underestimate the large brightness differences in the spectrum. These differences come out sharply when the color-tone is reduced or eliminated through the process of adaptation. A red is so rich, so saturated, so "taking," that we do not realize its small brightness valence; hence, when it begins to grow gray, it seems gradually to darken. One can easily convince oneself of this fact, by fixating monocularly for some time a good red, meanwhile

[1] Blue was a saturated color, and evidently did not quite reach the gray stage.

looking for an instant, from time to time, at the same stimulus with the unused eye alone. In this way one can bring the dulled and the original red, practically, side by side and easily compare them in brightness as well as in saturation. This method will also quickly bring the conviction that the phenomenon here in question is not a 'strip-phenomenon,' but rather that it embraces the whole field of visual sensation. The strip is no more truly affected than the background, and the background than its surroundings; its changes are more striking because it happens to be smaller, and because it lies in the focus of the attention. The phenomenon is no more an 'illusion' than is any change in visual sensation which is a result of the temporal course of stimulation.

THE PERCEPTION OF VISUAL FORM.[1]

By L. HEMPSTEAD, PH. B.

The object of the present Study is to record the perceptions set up by simple visual forms shown to the observer upon a background subliminally or liminally different from themselves. We wished to ascertain whether the illusory perception and associative completion of figures, exhibited under these conditions, obeyed any general law; whether constant individual differences could be made out, as between observer and observer; and whether the development of typical figures, as they passed through the stage of subliminal to that of liminal and thence to that of supraliminal difference from their background, followed any constant course. The problem proved to be more complex than we had supposed, and the results here published are only preliminary.

§ 1. METHOD AND APPARATUS.

The experiments were performed during the academic year 1899–1900. The apparatus used was that devised for another purpose by Leuba,[2] and modified by Whipple.[3]

The apparatus consisted (*a*) of a blackened tube, 50 cm. in length and 4 cm. in diameter. At a distance of 8 cm. before this stood (*b*) a rotating disc, 49 cm. in diameter, in which were cut 12 radial slits (20 cm. long, 10 mm. wide towards the periphery and 15 mm. wide towards the center of the disc) extending to a distance of 2 cm. from the outer edge of the disc. The disc was made of middle-weight junk-board, faced with gray paper. The electric motor which carried the disc was slung between upright wooden guides, in which it had a vertical movement of some 15 cm. The tube pointed through the upper portion (above the axis) of the disc: so that the lower the disc, the greater was the amount of gray interposed between tube and object. At a distance of 150 cm. from the disc was placed (*c*) a standard, carrying a gray card, 15.5 cm. square, upon which was pasted an outline figure of gray (about 7 cm. square, and 8 mm. in width of line). Only outline figures were used, as the limen for solid figures proved to be a good deal higher than that for outlines.[4] The gray of the background was the Milton-Bradley Co.'s neutral gray, no. 1; that of disc and figure was the slightly lighter warm gray, no. 1. The work was done in the dark room, and the necessary illumination produced (*d*) by two

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[1] From the Psychological Laboratory of Cornell University.

[2] *Am. Jour. of Psych.*, V, 376.

[3] *Am. Jour. of Psych.*, IX, 569.

[4] This is evidently due to the multiplication of 'lines of difference' in the outline figures. *Cf.* the difficulty with which the place of junction of several lines is perceived in the experiments cited below.

order of exactness of perception, the observers fall into 5 groups: *A*,—*R*,—*H*, *M*,—*W*, *L*,—*C*.

It does not appear that the type of the observer, or his general attitude towards the experiment, exerted any marked influence upon the experimental results. All that can be said is that the observers who knew nothing of the experiment, and were alert and objective in temperament, showed a somewhat slighter tendency to get a regular progressive series of illusory perceptions, and a much slighter tendency to see figures that bore no resemblance to the stimuli, than did the observers who were more suspicious and subjectively minded, and who knew or guessed something of the character of the experiment. Certain well defined tendencies of interpretation may be traced through all the records.

§ 2. The Various Forms of Illusory Perception.

The results of the experiment, under this heading, may be classified as follows.

A. *Perceptions which Bear a Definite Resemblance to the Stimulus.* Through all the hundreds of examples of these perceptions certain general and unifying principles may be clearly traced. They are:

I. For the more objectively grounded perceptions:

(1) The joining of different parts of a figure, *i. e.*, the formation of a continuous from a discontinuous figure. This joining may be:

(*a*) Of several isolated portions of a figure. This is irregular and rare, occurring most often where the figure is but feebly sensed. It may be the condition of several of the illusions given under B below. See Plate I, Fig. 1 *a a′*.[1]

(*b*) Of opposite end-points of a given line, or of a terminal point and a straight line. This joining occurs very frequently when the added line runs in a direction similar to that of lines of the figure: otherwise it is rare. Pl. I, Figs. 2 *a a′*, 3 *a a′*.

(*c*) Occasionally, of two lines whose junction can be effected by the continuation of a line in a direction parallel to itself. Pl. I, 4 *a a′*.

(*d*) See 2 *b* below.

The joining lines themselves may be:

(i) straight, so that the connection will be accomplished in the shortest possible way. Pl. I, 5 *a a′*.

(ii) a continuation of a given line,—hence taking its direction. Pl. I, 6 *a a′*.

(iii) curved, as if from mere indefiniteness of direction. Pl. I, 1 *b b′*.

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[1] The figures in the columns under the simple letters are the figures used as stimuli; those under the same letters accented show the interpretation put upon these figures by the observer.

(iv) of a form, the 'cue' to which is taken from the lines of the figure. Pl. I, 2 *b b′*.

(2) The continuation of lines. The lines of the given figure may be continued:

(*a*) Indefinitely and irregularly, when parts of the figure first begin to be sensed. Pl. I, 3 *b b′*.

(*b*) When by so doing two portions of the figure will be joined to form a more unitary whole. Pl. I, 4 *b b′*.

(*c*) When by the continuation a symmetrical figure will be produced. Pl. I, 5 *b b′*.

(*d*) When the continuation is in a direction similar to that of other lines of the figure. Pl. I, 6 *b b′*.

(3) The rounding of angles. When the angles of a figure first begin to be perceived, they appear round. This may possibly be an example of the joining of two portions of a figure, made possible by the higher liminal value of solid figures: the angles being rather solid than open forms. Very often the impression of roundness persists even after the angularity has been perceived. Pl. I, 1 *c c′*.

(4) The failure to perceive lines. It often happens that complete lines of a figure are not sensed, although the observer is confident that he has seen the whole form, and is ready to conclude the experiment. This tendency is especially marked when the lines are:

(*a*) Short and disconnected. Pl. I, 2 *c c′*.

(*b*) Included lines. Pl. I, 3 *c c′*.

II. For the more subjectively grounded perceptions:

(1) Tendencies affecting the number of lines.

(*a*) The addition of lines.

(i) What seem to be purely subjective lines appear, to a greater or less degree, with all observers, and are included in nearly all outline figures. They occur throughout the whole experiment, though seldom towards the end. They are very leeting and uncertain. It is unusual for them to persist for re than two observations, or to be at all constant whether different observers with the same figure or for the same erver and the same figure at different times. The only— that a dimly defined—underlying principle is that of sym-ry. Pl. I, 4 *c c′*.

) Lines which more definitely conform to rule are added they can be joined to the ends of given lines and run l to other lines. Pl. I, 5 *c c′*.

Uncertainty in regard to number of lines. Great un-y is shown as to the number of lines, especially in those in which a definite form or direction of line is repeated. 5 *c c′*, 1 *d d′*.

PLATE I.

(2) Those relating to the position of lines. When the figure is as yet very faint, great indefiniteness in respect to position is shown. Pl. I, 2 *d d'*.

(3) Those relating to the form of lines.

(*a*) Lines which are nearly straight are apt to seem straight. Even curved lines, when short or but slightly curved, occasionally appear straight at the beginning of an experiment. Pl. I, 3 *d d'*.

(*b*) Very occasionally, feebly sensed straight lines appear curved. Pl. I, 4 *d d'*.

(*c*) Very often the 'cue' to form is taken from a part of the figure, and applied from this to the whole. Pl. I, 5 *d d'*.

III. Individual Illusions. But one example of an illusion characteristic of only one observer was found. In figures which had a broken outline, *R* saw dark lines crossing the background and cutting the outline where incomplete. Pl. I, 6 *d d'*.

These illusions do not occur singly, but in all manner of combinations, the illusory lines themselves sometimes furnishing a basis for further illusions.

B. *Perceptions which Bear no Traceable Resemblance to the Given Figure.* Toward the beginning of the experiments, and often for some time during their progress, all sorts of figures were seen, which bore no apparent resemblance to the given figure (Pl. I, *M*, *W* 2, *C*).[1] For some observers—for *C* in particular—these figures formed a continuous, ever-changing series, lasting until the real form definitely appeared. For others, they came only occasionally, and often in isolated examples. Not only are the manner in which they appear, and the number of observations during which they remain unchanged, matters of great individual difference, but their number, form and variety are also most characteristic. Some 6 or 7 types of figures can be chosen for each observer, of which all other forms seen are but modifications. The types are quite [illegible]t for the different observers.

[illegible]tinction was made by the observers between these forms [illegible]ose which were undoubted modifications of the real

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[1] [illegible]wer part of Plate I shows the series of forms seen with a [illegible]re. The letters indicate the observers; the numbers below [illegible] inserted simply for convenience of reference. The figures [illegible]t represent the form given, and those still further to the [illegible]nding across the page, are the corresponding series of [illegible]. The small *t* indicates that first the one and then the [illegible] figures on either side was seen during a single observa- [illegible]mall numbers give the number of times that nothing was [illegible]all numbers placed above the figures give the number of [illegible]ese were successively seen. *W* 1 and *C* are fragments; [illegible]f figures in the other series has been slightly changed, [illegible]s are none the less typical.

figure. They were spoken of as mere 'impressions.' The line of difference was, however, not sharply drawn; and its drawing did not seem to be conditioned upon any necessary or intrinsic difference of perception. (1) At times, the 'impression' shows decided marks of being influenced by the real figure, while bearing no determinate resemblance to it. It often happened, *e. g.*, in the cases of *L* and *W* (Pl. I, *W* 2, 3), that the impression gradually changed, so as to become the real figure. (2) The impression occurred less often, and was less definite, when a plain gray card was substituted for the stimulus card. When we add to these facts (3) the extreme likelihood, rooted in the nature of the method, that the observer should utilize slight retinal stimulations for the building up of the final geometrical forms, we seem to be forced to the conclusion that the 'impression' and the more objective 'perception' are identical in kind. The apparently contradictory fact, that the impression often changed entirely from one observation to another, is still not incompatible with the theory of chance local excitability of the retina. Experiments are now in progress, whose object is by variation of method to test this hypothesis, and to account (if possible) for the form preferences of the individual observers.

§ 3. The Development of the Form.

The apparatus was so disposed that, for the first few trials, the observer saw no form, or at least had no more than an 'impression.' Presently, portions of the figure began to appear. The form might begin as a mere 'suggestion' of something, and then flash suddenly out; or it might develop regularly and gradually. What portion was seen first seems to have been a matter of accident, except that a long line was apt to be perceived earlier than a shorter one. The figure was at first extremely faint, in some cases coming and going so often that 4 or 5 partially different figures were seen during a single observation (Pl. I, *M*, *M* 1, *W* 3, 4). Occasionally, the whole figure would seem to move, or the lines to dance and flicker as their brightness fluctuated.[1] Gradually, in such cases, the figure would become clearer; a definitely marked outline replaced the narrow streaks of light, shading off into the background, which had at first held the attention. The illusions of § 2 were to be noticed from the moment that a form appeared at all. They might last to the very end of the experiment, though more often they disappeared as the figure became more definite. Now and again, an observer reported that he 'felt' an irregularity in the figure, before he was clearly aware of the

[1] G. M. Whipple: *Amer. Jour. of Psych.*, IX, 570.

nature of the irregularity (Pl. I, *W* 1). The simpler figures, and the more regular of the complex figures (those composed of parallel lines), were the more directly and the more correctly perceived; those figures produced the most illusions whose lines offered the most varied foundation for them.

SUMMARY.

(1) In looking at forms liminally different from their background, we are likely to continue lines and to complete figures, under the guidance of the two principles of symmetry and similarity. We are also likely to round angles, and to neglect certain lines altogether.

(2) On the more subjective side, we have but an indefinite idea of the number, form, and position of the component lines. Our perception is, again, guided by the principles of symmetry and similarity.

(3) Each observer has certain habits of illusion, or certain typical modes of associative completion, which persist with modification throughout his records.

ON THE CORRELATION OF MENTAL AND MOTOR ABILITY IN SCHOOL CHILDREN.

By WILLIAM CHANDLER BAGLEY, M. S., PH. D.,
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§ 1. INTRODUCTION.

In the fall of 1897 the writer began, under the direction of Professor Jastrow, of the University of Wisconsin, a study of the correlation of mental efficiency and motor ability in school children. The studies of Hancock[1] and Gilbert[2] in Worcester and New Haven, the investigations of Peckham[3] in Milwaukee, and the excellent work of Porter[4] in St. Louis, had paved the way for a study of this kind. The radical reforms in educational method, all directed upon a more complete recognition of the motor element in school work, seemed to demand such an investigation. The old proverb, "A sound mind in a sound body," had received an infusion of new life, and the principle which it adequately expressed found an extreme form of application in the elaborate organization of college athletics. At the same time, upon the intellectual side, the rise of a certain 'muscular' school of psychophysics, and still more, the prominence of a strenuous 'motor' cult in art and fiction, had done much toward giving an unusual importance to the motor aspects of education. All this was augmented from a strictly technical standpoint by the work of Porter who, after correlating the weight of St. Louis school children with their class-room records, found a marked tendency toward a direct relation between weight and mental 'precocity.' Weight, he then argued, easily stands for motor ability; hence the child increases in mental efficiency directly as he increases in motor ability.

The investigations upon which the following study is based

[1] Hancock, J. A.: A Preliminary Study of Motor Ability, *Pedagogical Seminary*, Vol. III, pp. 9-29. (October, 1894.)

[2] Gilbert, J. A.: Researches on the Mental and Physical Development of School Children, *Studies from the Yale Psy. Lab.*, Vol. II, pp. 40-100. (November, 1894.)

[3] Peckham, G. W.: The Growth of Children, *6th Annual Report Wisconsin State Board of Health*, Vol. VI, pp. 28-73. Madison, 1882.

[4] Porter, W. T.: The Physical Basis of Precocity and Dullness, *Transactions Academy of Science*, St. Louis. Vol. VI, pp. 161-181. (March, 1893.)

are far too limited in number to admit of wide generalization. The results, however, differ so radically from those of Porter that it is thought advisable to publish them, not with the belief that they will be accepted as conclusive in any respect, but with the hope that they may throw at least a glimmer of light upon some disputed points, as well as offer some suggestions which may be of value to future investigators.

§ 2. Data.

The data of the study are drawn from four largely independent sources, two contributing the motor and two the mental data; of each of these, one source was experimental, the other non-experimental.

A. The Experimental Sources.

(*a*) *Motor.* The motor data were obtained experimentally by means of tests designed to determine motor ability in five respects: (1) strength, (2) rapidity of voluntary movement, (3) accuracy of voluntary movement, (4) control of voluntary movement or "steadiness" of motor co-ordination, (5) amount and character of involuntary movement. The apparatus used in the determination of these points will be described in detail later. The tests were designed to include the most important factors in motor ability, excellence in motor ability being measured by the strength, accuracy, rapidity, and steadiness of voluntary movement, accompanied by a minimum of involuntary movement.

(*b*) *Mental.* The experimental sources of the data on mental efficiency consisted of various types of reaction times as representing quantitatively the mental ability of the subject, mental excellence being represented by the alertness of the mind in reacting appropriately to given stimuli. These tests, which form an entirely independent study, were conducted by Miss Agnes Chapman, of the University of Wisconsin, as the basis for a baccalaureate thesis.

B. Th[illegible]on-experimental Sources.

(*a*) [illegible] The teachers in charge of the various pupils test[illegible]n estimate of the motor ability of the pupils as they had [illegible] it in the process of the school work. The pupils w[illegible] as "very clever," "clever," "medium," "awk-[illegible] "very awkward." These terms were later trans-[illegible]numerical symbols for convenience of manipulation.

[illegible]*al.* The mental data of a non-experimental type [illegible] in two ways. (1) From class-standings, as recorded [illegible] registers: the purely motor studies—writing and [illegible]ere eliminated, and the remaining standings aver-

aged upon a scale of 100 as numerical criteria of mental ability. (2) In order to eliminate the error that might arise from differences in standards used in marking by the several teachers, the estimates of the latter were again recorded,—this time the estimate of mental ability (independent of class records) being taken.

C. Auxiliary Data.

(*a*) *Personal.* The name, age, and grade of each pupil tested were recorded and spread upon the records of the tests together with the experimental data.

(*b*) *Anthropometric.* As material for possible correlations the following facts concerning each subject were recorded: weight in kg., height in mm., breadth of the head and length of the head,—taken at the usual points,—both in mm.

§ 3. APPARATUS AND METHOD.

Professor Jastrow's card-sorting apparatus was used in obtaining the reaction-times of the pupils. It will be found fully described, both as to structure and use, in the report of the American Psychological Association for 1897.

Following are brief descriptions of the various pieces of apparatus used in the motor tests, and of the methods employed:[1]

(*a*) The Test for Strength.

(1) *Apparatus.* For this test a dynamometer of a peculiar type was constructed. To the side of a fixed rectangular wooden frame, standing about 55 cm. from the floor, a spring balance was attached. An upward pull on the lower of a pair of grip-handles was transmitted by a lever movement to the spring of the balance. This balance was fitted with the usual recording scale; but in order to render the readings more exact the scale was discarded in practice, and its pointer used to move an arm 10 cm. long, so fixed upon a pivot that the free end described an arc of sufficient amplitude to admit of small graduations. The scale was then determined empirically, and graduated in kg.

(2) *Method.* The grip-handles were adjusted by thumb-screws to the desired distance (which, of course, varied with the size of the subject's hand); the height of the standard was not adjustable, but two small movable platforms rendered the apparatus available for subjects of all heights. Each subject was given three trials, being directed each time to grip the handles as tightly as possible with the right hand. The readings were recorded and averaged.

(*b*) The Test for Rapidity of Movement.

(1) *Apparatus.* "Trilling" a Morse key with the right forefinger was the test used to determine rapidity. The key was connected *(a)* with a dry battery of two cells, and *(b)* with an automatic recorder. The entire apparatus was securely fastened to a board (37.5 cm. square) which was placed on a table of the size used in the kindergarten.

(2) *Method.* The subject was seated before the table and directed to "trill" the key as rapidly as possible. As soon as the subject was able to manipulate the key readily, the operator switched in the current which started the recorder. The current was kept on for 10 seconds,

[1] The interested reader may be referred to the discussion of apparatus in the course of a study on a topic related to the present, by W. L. Bryan, *Amer. Jour. of Psych.*, V, pp. 125-204.

at the end of which time the operator opened the switch, the subject continuing to operate the key for a few seconds after the current had been shut off. Three successive records were taken in this way, and the results averaged.

(*c*) The Test for "Steadiness" of Motor Co-ordination.

(1) *Apparatus.* For this test a complicated scroll-plate was devised. A thin sheet of tin-foil was carefully smoothed out and waxed upon a piece of plate glass. Upon this foil a scroll diagram was first traced out and then cut, leaving a slit 1 mm. wide. This slit was continuous through all the complications of the scroll, but for convenience its course was divided into four sections, each representing a peculiar type of movement. The positive pole of the battery was connected with the edge of the foil, the negative pole with a tracing needle made by inserting a sewing needle into the end of a pencil holder and connecting it with the battery by means of a fine wire.

(2) *Method.* The scroll-plate was fastened upon the board used in the rapidity test, the subject was seated before it, given the pen, and directed to trace the pattern, being cautioned that he was to keep to the middle of the slit, every failure to keep away from the foil being recorded by a tap of an electric bell which was thrown into the circuit. The taps of the bell were recorded for each section of the scroll, as well as the time for each section, the total number of taps, and the total time.

(*d*) The Test for Accuracy and Constancy of Voluntary Movements.

(1) *Apparatus.* This test was made by a recording target (30 x 30 cm.) mounted upon a table (like the one used in the last two tests), the target being inclined backward to make an angle of 45° with the table-top. The target consisted of a wooden frame with a solid back, the frame being fastened to the back by means of hinges. Into this frame a sheet of paper was inserted having marked upon its center a black bull's eye 10 mm. in diameter. Behind this were a sheet of carbon paper and a sheet of record paper upon which the impressions were preserved.

(2) *Method.* The subject was placed two m. away, facing the target, and was prevented from approaching nearer by a movable upright. He was given ten marbles and directed to toss them, one at a time,—attempting to strike the bull's eye at each trial. After the ten marbles had been tossed the sheet was removed (after first receiving the impression of the bull's eye for reference in later measurements). This process was twice repeated, making three records in all.

These records were treated in two ways. In the first place the distance of each impression from the center was measured in mm. for the determination of the constant error of each sheet. The constant errors of the three sheets belonging to each subject were then averaged, and the result recorded as an index of motor accuracy. Then the average error was computed (per cent.) for each sheet, the three percentages of each subject being again averaged as an index of constancy of movement.

(*e*) The Test for Amplitude of Involuntary Movement.

(1) *Apparatus.* The apparatus used for determining the amplitude of involuntary movement was the automatograph designed by Professor Jastrow and known by his name. A full description will be found in the *American Journal of Psychology*, Vol. IV, pp. 398-407.

(2) *Method.* The automatograph was placed upon the table, the subject being directed to stand before it in such a position that the median plane of his body made an angle of 45° with the edge of the

automatograph opposite the recording pencil. The attention of the subject was then concentrated upon a metronome placed upon a table two m. in front of him. This metronome was set at 120 beats per minute, and the subject was directed to count the beats up to 120, raising his right hand and resting it, tips of the fingers down, upon the upper plate of the automatograph, when he began to count. At the same time the operator dropped the pencil upon the recording plate, leaving it there until the subject had completed the counting. Three records of this kind were taken. The total amplitude of movement was measured upon each record by means of a sliding compass, the average of the three record-amplitudes thus obtained being taken as an inverse index of the subject's excellence in the test. While every precaution was taken to make these measurements as exact as possible, they must still be interpreted rather as approximations than as exact determinations.

§ 4. Results.

The tests were begun December 13, 1897, at the Fifth Ward School, in Madison, and continued daily (during the school sessions) until the first of May, 1898. Each test occupied from twenty-five to forty-five minutes, the average being about thirty-five minutes. In all one hundred and sixty tests were made for motor ability, and one hundred and seventy-five for mental ability (reaction-times). Of these two series of tests one hundred and ten were upon the same pupils. For both tests additional data were collected from the school records and from the teachers' estimates as described above, but only for those who underwent the motor tests were anthropometric data tabulated.

Method of Treating the Data. The entire 'motor,' 'personal' and 'anthropometric' data were spread upon four large sheets of ruled paper. In this way the material was arranged in such a manner as to render it easy of manipulation. To the data thus arranged were added from time to time the class standings of the subjects as obtained from the teachers' registers and the teachers' estimates of mental and motor ability as translated into numerical terms, together with the "indices" (to be described later) of the mental alertness and motor ability of each subject as gained from the tests upon reaction-times, and from the motor tests.

The data as thus arranged were first examined with a view to determine general relations. The various columns were averaged, and from these averages curves of distribution were plotted.

Aside from this general treatment special correlations were made in the following manner.

The quantitative results of each important test were divided into five classes of thirty-two subjects each, the thirty-two having the highest records in each case being placed in the first class (designated Class AA), the thirty-two having the lowest being grouped in the last class (Class XX), while the remain-

ing ninety-six were similarly grouped into three intermediate classes (Classes A, M and X) in the order of their excellence. The data as arranged in this way for each test were spread upon separate sheets (one sheet for each class), and upon these same sheets were also placed the remaining data—mental, motor, personal, or anthropometric—which we wished to correlate with the given test, each line of figures across the page representing the results given by the same subject in the various tests. The vertical columns were then averaged, and a single correlation was completed.

An example of the process may make it clearer. We will suppose the results of the dynamometer test to have been arranged in five groups as just described. It is desired to correlate with this dynamometer test the standing obtained from the school registers. Along with the transfer of the dynamometer standings from the general sheet to the correlation sheet, the class standings are also transferred, the dynamometer record of each pupil being placed upon its appropriate sheet and the class standing of the subject represented being placed in an adjacent column. When the vertical columns are averaged, the general average dynamometer standing of the thirty-two subjects who were the best in the test is shown, and beside it is the average class standing of these thirty-two best dynamometer subjects. By this means, after averaging the remaining sheets in the same way, we arrive at what we may term a single or simple correlation, that is, a correlation of five groups, of a more or less uniformly varying scale of excellence in the given test, with the average class standings of these same groups. From this a curve may be plotted, the five averages of the correlating test being the five points of the curve as measured from one co-ordinate in terms of the five averages of the data with which the given test is correlated.

This method may be complicated by the following process. After making a simple correlation as above, arrange the data which have been correlated with the given test in five similar groups of thirty-two subjects each, arranged in the order of excellence as represented by these data.

To continue the above instance. If, after correlating the dynamometer test with the class standings singly as was described, it is wished to make a double correlation, the class standings may be arranged in five classes according to their degrees of excellence. Beside each subject's class standing, his dynamometer test may be recorded. These sheets, averaged as before, will give the average dynamometer results for each group of subjects arranged in order of class standings. If a curve is plotted from this latter correlation upon the same co-ordinates as the curve of the former correlation, and if care is taken to have the order of excellence in each case proceed from left to right upon the abscissa, and from below upward upon the ordinate, the following conditions may be observed:

(1) If the two curves have a general N. E. (northeasterly) direction (*i. e.*, from the meeting point of the co-ordinates to the upper right hand corner of the cross-section sheet), the correlation is direct; *i. e.*, the order of excellence in the one case bears a direct relation to the order of excellence in the other case.

(2) If the curves have a general S. E. (southeasterly) direction, the

correlation is antagonistic, *i. e.*, the order of excellence in the one case bears an inverse relation to the order of excellence in the other case.

(3) If the curves cross each other at right angles, the correlation is indifferent, the degree of indifference depending upon the degree to which the angle approaches 90°.

It may be well to add that these conclusions can be reached less satisfactorily from the single correlations, the general direction of the single curve giving some index as to the character of the correlation,—always providing that the order of excellence is as described above.

The Motor and Mental Indices. The terms "motor index" and "mental index" appear in several places in the Tables. The motor indices were derived as follows: The results of each test were arranged in the precise order of their excellence; the highest was then given an arbitrary value, 999, the others were given values in order down to 840 (which exhausted the 160 subjects). The process was completed for five tests, viz., the tests for rapidity, accuracy and steadiness of voluntary movement, the test for strength, and the test for amplitude of involuntary movement. Then these five motor standings of each subject were averaged, and an arbitrary symbol was obtained which represented the motor ability of each subject. This was called the motor index. Proceeding in the same general way we obtained a mental index from the mental tests and from the class-records. This mental index was taken to represent mental alertness, the handling time involved in the reaction experiments having been determined and eliminated.

The Teachers' Estimates. These were translated into numerical terms according to the following scheme. Motor ability: very clever, 5; clever, 4; medium, 3; awkward, 2; very awkward, 1. Mental ability: very bright, 5; bright, 4; medium, 3; dull, 2; very dull, 1.

§ 5. Interpretations and Conclusions.

(*a*) Comparisons of the various Motor Tests with the Class Standings. Double correlations.

In the following Tables the data mentioned first form the criteria for the division into the classes,—AA, A, M, X and XX. That is, in the first part of the following Table the class AA represents the thirty-two subjects who stood highest in the test for strength; the average of the class standings of these thirty-two is given directly below the figures which indicate the number of kg. which they registered on the dynamometer. In the second part of the Table the class AA represents the thirty-two who had the highest class standings. The average dynamometer 'pull' of *these* thirty-two is placed directly below their average class standing.

TABLE I.

Correlation of the Test for Strength and Class Standings.

CLASS.	AA.	A.	M.	X.	XX.
Dynamometer,	33.0	25.9	22.0	18.0	13.1
Standings,	75.4	80.0	83.97	85.71	82.92
Standings,	92.7	85.7	83.0	74.0	67.9
Dynamometer,	21.3	19.7	22.3	24.7	25.8

The above Table shows a decidedly inverse relation between mental ability, as indicated by class standings, and motor ability, as indicated by the dynamometer records.

TABLE II.

Correlation of the Test for Rapidity of Voluntary Movement and Class Standings.

CLASS.	AA.	A.	M.	X.	XX.
'Trilling,'	65.51	56.96	53.89	48.42	40.33
Standings,	80.31	82.18	85.90	79.39	79.30
Standings	92.7	87.5	83.0	74.0	67.9
'Trilling,'	52.3	50.7	53.4	51.6	53.6

This Table, in both its parts, is not conclusive. If the curve were plotted it would be 'indifferent.'

TABLE III.

Correlation of the Test for Steadiness of Voluntary Movement and Class Standings.

CLASS.	AA.	A.	M.	X.	XX.
'Tracing' Errors,	68.6	115.28	145.5	176.7	229.2
Standings,	78.1	81.44	77.1	82.45	90.88
Standings,	82.7	87.5	83.0	74.0	67.9
'Tracing' Errors,	164.8	145.0	133.1	135.1	136.3

A curve plotted from Table III would show a decidedly inverse relation between mental ability, as indicated by class standings, and motor ability, as indicated by the tracing test.

TABLE IV.

Correlation of the Test for Accuracy of Voluntary Movement and Class Standings.

CLASS.	AA.	A.	M.	X.	XX.
'Target' Test,	74.2	99.3	112.2	127.7	149.0
Class Standings,	78.2	78.5	84.3	81.8	83.9
Standings,	92.7	87.5	83.0	74.0	67.9
'Target' Test,	113.1	116.2	108.4	95.9	102.5

This Table, like the preceding, shows a predominantly inverse relation between motor ability and mental efficiency. The curve which might be plotted from it would, however, be less uniform than that of Table III.

TABLE V.

Correlation of the Test for Amplitude of Involuntary Movement and Class Standings.

CLASS.	AA.	A.	M.	X.	XX.
Automatograph,	46.3	69.9	86.9	98.9	137.9
Standings,	81.8	81.9	81.4	82.5	79.0
Standings,	92.7	87.5	83.0	74.0	67.9
Automatograph,	86.0	83.2	93.4	83.6	82.8

The curve from Table V would probably be classed as 'indifferent,' although it would show a very slight tendency toward the 'direct' relationship.

TABLE VI.

Correlation of the Test for Constancy of Voluntary Movement and Class Standings.

CLASS.	AA.	A.	M.	X.	XX.
Constancy Index,	29.12	34.3	39.7	42.8	51.7
Standings,	81.51	85.03	76.73	83.50	81.6
Standings,	92.7	87.5	83.0	74.0	67.9
Constancy Index,	40.5	40.3	39.5	41.8	38.9

The curve for Table VI would be rather less 'indifferent' than the curve for Table V, and the tendency would be toward an 'inverse' relation.

TABLE VII.

Correlation of the General Motor Index and Class Standings.

CLASS.	AA.	A.	M.	X.	XX.
Motor Index,	961.8	938.3	924.3	909.0	881.9
Standings,	77.8	80.0	83.6	83.8	84.7
Standings,	92.7	87.5	83.0	74.0	67.9
Motor Index,	917.2	907.1	922.8	931.0	931.05

In this Table the individual discrepancies of the preceding Tables are eliminated, and the curve would show a very marked inverse relation between motor ability, as represented by the various tests, and mental efficiency, as represented by the class standings.

(*b*) Comparisons of the Teachers' Estimates of Mental Ability with Class Standings and with the Motor Index.

TABLE VIII.

Correlation of Teachers' Estimates of Mental Ability and Class Standings.

CLASS.	AA.	A.	M.	X.	XX.
Estimates,	4.62	4.0	3.16	2.87	1.59
Standings,	90.5	86.28	77.0	82.43	71.9

This single correlation indicates that there is no appreciable discrepancy between the teachers' estimates of mental ability

and the values taken from the class records as representing mental ability.

TABLE IX.

Correlation of the Teachers' Estimates of Mental Ability and the Motor Index.

CLASS.	AA.	A.	M.	X.	XX.
Motor Index,	961.8	938.3	924.3	909.0	881.9
Estimates,	3.32	3.15	3.46	3.36	3.34
Estimates,	4.62	4.0	3.16	2.87	1.59
Motor Index,	908.0	924.4	901.6	913.3	926.8

While this Table lacks the uniformity of Table VII, the inverse relation is more than indicated.

(*c*) Comparison of Reaction Times with Class Standings and with the Motor Index.

TABLE X.

Correlation of Reaction Times and Class Standings.

CLASS.	AA.	A.	M.	X.	XX.
Reaction Times,	13.5	15.7	17.1	19.0	22.7
Standings,	78.8	82.2	80.6	82.3	77.3

This Table shows a discrepancy between the indices of mental ability as represented by class standings and by reaction times. The relation, however, is not inverse, but rather indifferent, the children whose reaction times are nearest the norm having the best class standings, while those who are particularly alert and those who are particularly slow in reaction are alike deficient in mental efficiency as represented by the class standings.

TABLE XI.

Correlation of Reaction Times and Motor Index.

CLASS.	AA.	A.	M.	X.	XX.
Reaction Times,	13.5	15.7	17.1	19.0	22.7
Motor Index,	928.6	930.9	935.2	928.6	935.2

Table XI, like Table X, is inconclusive, but shows a tendency toward an inverse relation between mental ability, as represented by reaction times, and motor ability, as represented by the motor index.

(*d*) The Elimination of the Age Factor.

In the above determinations the tendency toward an inverse relation between mental and motor ability is quite decided, even when mental ability is represented by two values as indifferent as regards each other as are the reaction times and the class standings. The factor of age, however, has not been considered, and it might very well be possible that this variable factor would compensate the differences which we have found. The

results which were obtained demonstrated conclusively that general motor ability increased with growth, but the relation between growth and mental ability was not so clearly shown. There is no alternative, therefore, but to eliminate in one way or another the factor of age. To do this the following course was pursued. The subjects were divided into five groups of thirty-two each upon the basis of age, the thirty-two oldest subjects being placed in Class AA, the thirty-two youngest in Class XX, and the remainder divided between Classes A, M and X in the order of age. Each of these classes was then treated exactly as the entire one hundred and sixty subjects were treated in the first instance, except that each was divided into four classes of eight subjects each, instead of into five classes of forty subjects each. The principle of division varied according to the information which was desired. Each Class (AA, A, M, X, and XX) was, for example, divided into groups of eight with regard to the motor index, or with regard to weight, or with regard to mental ability. In the last named case a slight departure was made from the former treatment. A 'mental index' was established for each subject in exactly the same way that the motor index had been established, except that only the class standings and the reaction times were used in the determination. By the aid of these mental and motor indices the comparison of mental ability and motor ability can be made with much more nicety than was possible under the former procedure.

TABLE XII.

Comparison of Mental and Motor Ability with Age Factor eliminated.

	Range of Age.	Av'age Age.	Class AA. (Best Average Motor Index.)		Class A. (2nd best Av. Motor Index.)		Class X. (3rd best Av. Motor Index.)		Class XX. (Lowest Av. Motor Index.)	
			Motor Index.	Mental Index.	Motor Index.	Mental Index.	Motor Index.	Mental Index.	Motor Index.	Mental Index.
AA	14–17	14.79	962.1	894.6	941.2	894.7	930.5	927.3	908.0	929.3
A	13–14	13.7	967.9	903.6	947.8	925.8	935.2	919.8	899.6	930.7
M	12–13	12.53	943.3	939.5	921.0	927.6	912.4	921.2	887.6	901.6
X	12–12	12.0	944.8	952.2	931.1	950.1	912.8	942.5	881.4	938.5
XX	8–11	10.6	926.5	944.5	902.2	948.3	889.9	958.0	874.5	934.2
	Averages.		928.9	906.8	928.6	909.3	916.1	933.7	890.2	926.8

1st half, average motor index, ... 928.7
" " " mental " 908.0
2d half, average motor index, ... 903.1
" " " mental " 930.2

The above Table shows very plainly the general tendency toward an inverse relation between mental and motor ability.

also shows that the law—if it be a law—is subject to
ous individual variations; and the discrepancies, espe-
in Class X, indicate that at certain periods of growth the
n between the two factors may be quite the reverse of the
n in general.

TABLE XIII.

Comparison of Weight, Class Standings and Motor Ability with the Age Factor eliminated.

(Range of age and average age same for each class as in Table XII.)

		Class AA } Highest Av. Weight.			Class A } 2d Highest Av. Weight.			Class X } 3d Highest Av. Weight.			Class XX } Lowest Av. Weight.		
		Weig't.	Motor Index.	Class Standings.	Weig't.	Motor Index.	Class Standings.	Weig't.	Motor Index.	Class Standings.	Weig't.	Motor Index.	Class Standings.
Oldest	AA	131.7	947.6	73.2	113.1	926.3	78.3	100.4	935.9	70.8	86.0	939.2	74.5
2d Oldest	A	105.1	930.4	74.8	92.6	958.2	77.7	86.9	929.7	74.2	77.2	929.3	78.5
3d Oldest	M	90.5	915.6	80.0	81.5	918.9	83.0	75.0	919.5	84.2	65.4	911.2	85.1
4th Oldest	X	101.2	922.6	85.2	88.2	912.2	85.6	78.2	920.3	90.5	69.8	909.4	83.8
Youngest	XX	89.2	905.2	85.2	73.2	896.7	88 7	66.8	894.2	84.7	57.7	897.6	86.2
Averages		103.7	924.2	79.6	89.7	922.4	82.6	81.4	919.9	80.8	71.2	917.3	81.6

1st half, average weight,	96.7
" " motor index,	923.3
" " class standings,	81.1
2d half, average weight,	76.3
" " motor index,	918.6
" " class standings,	81.3

Table does not indicate such a direct relation between
and mental ability as Porter found in his investiga-
upon St. Louis school children. On the other hand,

the relation between weight and motor ability, with the age factor eliminated, while slightly direct, is mainly indifferent.

(*e*) Other Correlations.

The correlations which have been given above did not exhaust the data collected. Each set of determinations—personal, anthropometric, motor and mental—was correlated with every other set of determinations, with the hope of discovering some uniform relation between the various factors. To present the complete Tables exhibiting these correlations would, of course, be quite out of the question within the limits of the present paper. Some of the more important conclusions are, however, indicated in the following summary.

SUMMARY.

1. Under the conditions of the investigation, and with the children that were tested, there is a general inverse relation between motor and mental ability; those who are the 'brighter' pupils and those who have the quicker reaction times being, as a rule, deficient in motor ability, while those who are best developed physically, who are the strongest, who have developed motor 'control' to the greatest extent, are generally deficient in mental ability. This rule, however, was found, with the children tested, to have numerous individual exceptions, and a varying validity at different periods of development.

2. There seems to be little direct relation between mental ability as represented by reaction times, and mental ability as represented by class standings, except that excellence in either of these directions is apt to be accompanied by a deficiency in motor ability.

3. There is a gradual increase of motor ability with age. The increase in mental ability is not so well marked.

4. In general, the boys slightly surpass the girls in motor ability, while the reverse obtains in mental ability.

5. Regarding cranial capacity as indicated by the head girths, we notice a significant trend toward an inverse relation between mental ability and head girth.

EXPERIMENTAL STUDY OF THE MENTAL PROCESSES OF THE RAT. II.

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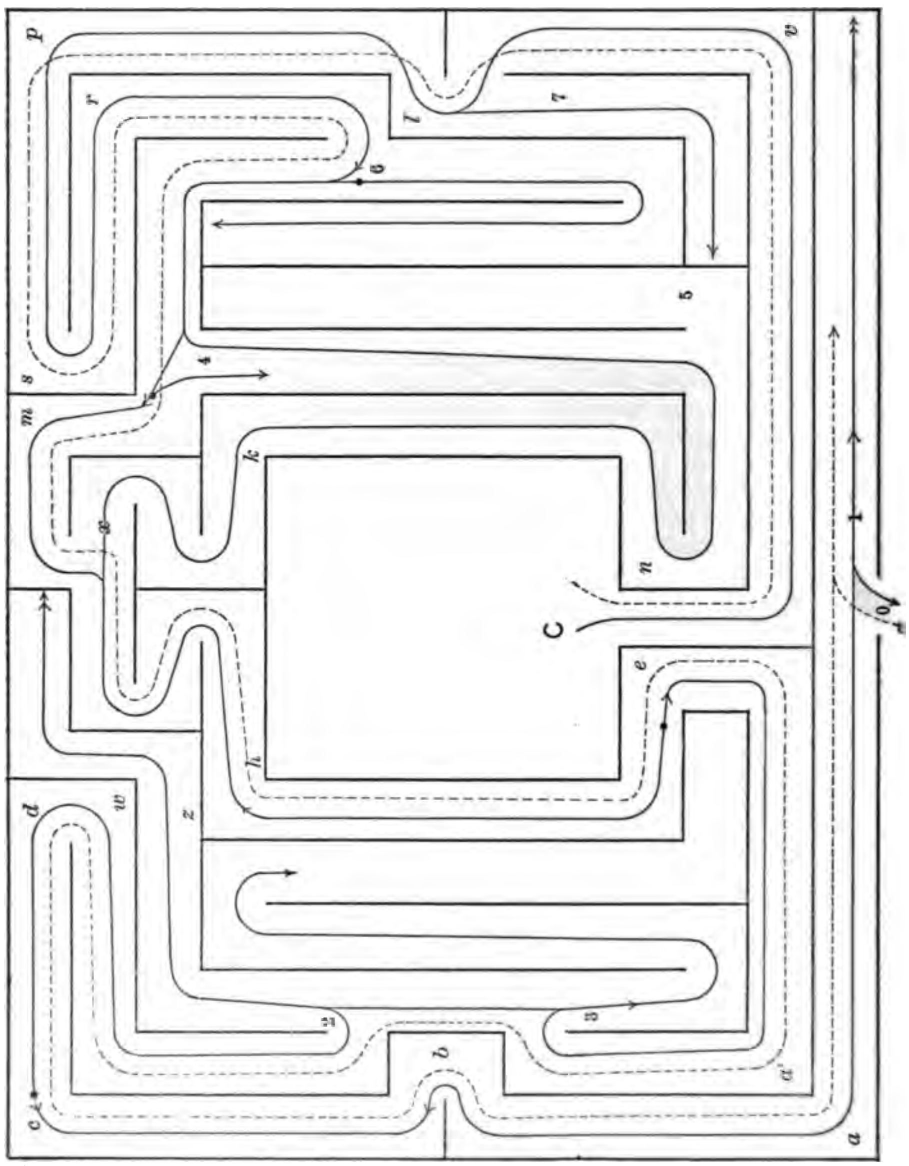
The present paper, which supplements, in a measure, two former papers, (*Am. Jour. Psy.* Vol. XI, Nos. 1, 2), presents in detail the results of some further experimental studies upon the mental life of the rat. Primarily a study in method, an attempt to observe this animal under approximately experimental conditions, the methods and devices have worked well enough to warrant considerable confidence in the results, and the inferences therefrom. The paper describes the apparatus used and the conditions of experiment, gives a detailed account of a typical series of experiments, compares the intelligence of wild rats and the tame white rats (same variety) upon the basis of these experiments, discusses briefly the general form or character of animal intelligence, and makes some suggestions in regard to the mental facts involved in solving the problems set in the tests. It is not in any sense a systematic rat-psychology.

Apparatus and Conditions of Experiments.

The aim in these experiments, as indicated above, was to make observations upon the free expression of the animal's mental processes, under as definitely controlled conditions as possible; and, at the same time, to minimize the inhibitive influence of restraint, confinement and unfamiliar or unnatural circumstances. Fear, which in lack of a better term, may be used to include the three influences just noted, and too great difficulties are the things most rigorously to be guarded against. On the positive side, the experiments must conform to the psycho-biological character of an animal if sane results are to be obtained. This is not the same thing as guarding against "too great difficulties." The difficulty of two tasks, judged by their complexity and the quality of intelligence necessary for heir performance, may be identical; yet the problem involved the one may be so different from that in the other, so remote n the animal's racial experience and life habits as to be ab- tely outside his capabilities. A human being has to know the elements of an action feel—or better, has to know the r of the elements—in order to perform the action. The

importance of these characteristic differences is obvious enough where structural differences provide the basis: no one would



expect a buffalo and a rabbit to do the same things in the same way. No less important, though less easy to define and designate, are the specifically psychic traits of an animal which constitute its character, and which depend in the main upon its biological conditions. The cat and the rat are not antithetical in structure, nor do they differ very widely in degree and kind of intelligence; but their life habits, both on the emotional and the intellectual side, present an effective contrast. The cat, primarily a hunter, is bold, independent, and aggressively open; the rat, on the contrary, primarily the hunted, and only secondarily a hunter, is timid and furtive. His timidity is comparable to an intellectual obsession. His boldness when displayed is impudent and half apologetic, never self-contained and unconscious like that of the cat. I daily see this matter exemplified in the case of a pet rat and a young cat. Though the rat has compelled the cat to respect his rights, the characteristic difference of mental attitude is not greatly changed.[1]

Conforming with such considerations, appeal was made to the rat's propensity for winding passages. A recent magazine article upon the Kangaroo Rat, by Mr. Ernest Seton Thompson[2] illustrates well the radical character of this rodent trait. Mr. Thompson gives a diagram of the Kangaroo Rat's home-burrow, the outline of which bears a striking resemblance to that of the apparatus used in these experiments. It suggests that the experiments were couched in a familiar language. Not only do they conform to the sensori-motor experience of the animals, but they also fall in with their constructive instinct relative to home building.

The Hampton Court Maze[3] served as model for the apparatus. The diagram given in the Encyclopedia Britannica was corrected to a rectangular form, as being easier of construction. The character of the problem was not affected. Three mazes were made. The first was as follows. The dimensions were 6 by 8 feet. The bottom was of wood, the boards being fastened together so as to make a portable whole of the apparatus. All the rest: top, sides, and partitions between galleries were of wire netting, ¼ in. mesh. The height of the sides was 4 inches; the width of galleries, the same. In the center was a large open space. The accompanying diagram gives the ground plan of the maze. The entrance is marked by the figure *O*. Figures *1* to *7* indicate seven blind alleys—seven

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[1] The character of the white rat is modified somewhat by its immemorial life of captivity, but less than might be supposed. All the primitive traits emerge under the appropriate conditions.

[2] Scribner's Magazine, April, 1900.

[3] *Cf.* Ency. Brit. Art. "Labyrinth."

possibilities of error. It will be observed that *4* does not lead necessarily into the *cul-de-sac 5*, but does inevitably furnish a chance for error. The letter *x* marks a dividing of the ways either of which, however, may be followed without completely losing the trail. Certain other points are indicated by letters *a*, *b*, *c*, etc., for convenience in description. C stands for center. A glance at the maze will be sufficient to convince one of the difficulty of the problem. This maze is designated as Maze I. The two other mazes were identical with this, except that they were made throughout of wire netting, bottom as well as top and sides. The apparatus could thus be reversed and a mirror reproduction of the original form could be obtained. In use they were fastened temporarily to wooden floors. These mazes will be spoken of as II and III. In all cases the mazes were placed upon tables 2½ feet above the floor. The floor of the maze was covered with sawdust. This was renewed whenever a new rat was introduced.

To obviate the affective disturbance which would have resulted from change of conditions just prior to experiment, as little difference as possible between the conditions of experiment and of ordinary experience was allowed. The event frequently justified the precaution. The rats were kept in an ordinary observation cage,[1] a well ventilated and commodious apartment, standing flush with the maze at *O*. Back of the cage, upon the same table, was a screen completely concealing the observer during experimentation, but permitting him to look down upon the maze and mark every movement of the rats. When ready for experimenting, the sliding glass door which closed the passage into the maze was lifted by means of a pulley connection running over the screen. This door always opened with slight noise and friction. Food was placed in the central enclosure. To obtain this, the rats had to find their way through the tangled maze. They were kept hungry enough so that they would set about the task vigorously. Experimenting was done in the evening to minimize the influence of distracting noises.

In spite of these precautions there was, as might be expected, some lack of uniformity in the results—so much has to be allowed to the internal conditions and to individual variation.

As a beginning, two series of experiments were made; one with wild brown rats, *mus decumanus;* the other with white rats, albinos of the same variety. The original purpose was to use the wild rats exclusively; but the difficulties were considerable, and the white rats were found to serve the purposes of experiment quite as well in every way. In all the experiments after the first series white rats were used. The most of the later

[1] *Cf. Am. Jour. Psy.*, X, 3, p. 135.

experiments were made to determine special points, and will be described in their immediate connections.

As before stated, the rats were let into the maze at the time of experiment and were left until the following morning. The entire night was theirs for investigating the maze. This method excludes the possibility of a quantitative study, and intentionally, for reasons given within.

DESCRIPTION OF EXPERIMENT.

In presenting the results of these experiments I give a detailed account of a typical series, following this with explanatory suggestions. The conduct of the rat is described as it was minutely recorded at the time of observation. This is supplemented in passing by comparison with other experiments and by details taken from them. This plan of presentation has the advantage of exhibiting in detail the method of animal intelligence in actual operation,—it is analogous with vital staining in histology—rather than in figuring its general form as could be done by the method of graphic representation in curves. Again, in view of the rôle one's own prepossessions and limitations are bound to play in interpretation, it will be an advantage for the reader to know the observed facts upon which the writer's interpretations are based. I readily concede that my facts may be found more valuable than my inferences. Be that as it may, all who are interested in comparative psychology will agree that careful and impartial description of the objective facts of animal intelligence is a desideratum.

I have selected for detailed description my second series of experiments. The subjects were two young male white rats, about 3½ months old. They were perfectly tame—pets from birth.[1] Nine experiments were made at intervals of two days; and a tenth after a lapse of three weeks. The conditions were the same as with the wild rats of the first series.

Before giving this detailed description I wish to present a brief summary of the observations upon the wild rats in series 1, in order to make clear the passing comparison, given within, between the wild and the tame rats. This comparison is purely a by-product of the study—it was not contemplated at all in the beginning—and it takes us a little out of the straight line of exposition; but the results have a suggestive value sufficient to warrant the delay.

The subjects of Series I were three adult wild rats—a male and two females. They had been in captivity about three months, but were in perfect physical condition. No particular

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[1] Rats A and B of Group V, reported in *Amer. Jour. Psy.*, Vol. XI, No. 2, pp. 156 ff.

effort had been made to tame them except by excluding as far as possible occasion of fright. They remained so wild, however, as to necessitate the extreme precautions described above.

The first two experiments failed of definite results because of imperfect conditions. The rats were frightened by external disturbances, so that they failed to move (Exp. 1,) for more than 10 m., and did not reach C in two hours. This they accomplished during the night in each case. It was not until Exp. 3 that the conditions were made to conform perfectly to the description above. After that, observation was made and results recorded more satisfactorily. The influence of the first two trials is apparent in Exp. 3, the journey being made in 15 m., and with 8 errors.[1]

In this experiment and in all succeeding experiments ot the series the male showed striking superiority to the females. In this case they did not reach C until 15 m. after the male — indeed they did not leave the cage till after he had reached C and was well on his way back to the cage. He met one of the females at *c*. Under the same stress of hunger, they exhibited throughout the series very much less boldness and initiative. This humbler character comes out again in the deference the females showed the male. Whenever he was monopolizing the food they would make furtive attemps to steal the prize, or approach with deprecating squeaks as if begging to be allowed to share. On several occasions I saw him chastise a female severely for trying to get the food away. The females, too, were less apt in familiarizing themselves with the maze. In the fifth experiment, I observed that they showed little familiarity or assurance, and seemed much more disconcerted than the male when they got into a blind alley. The male died after Exp. 7, but even after that the improvement of the females was relatively slow. Four more experiments showed slight gain. Their timidity seemed to abate but little, and prevented them from giving full attention to the problem.

Later tests with male and female white rats gave the same general result, though the difference was not so marked. In only one case out of ten or twelve pairs observed did the female show equal initiative. The significance of this is not, I think, that the intelligence of the males is higher or more refined, but, rather, that it is more effectual by reason of being less subject to affective disturbances and inhibitions. The case is analogous with a point made later in comparing the white and the gray rats: the appearance of greater intelligence really may mean

[1] By errors I mean the returns—*e. g.*, going back from *d* to *a*—as well as the positive errors of following wrong paths.

nothing more than that one animal is somewhat more energetic than another, moves more and faster, and consequently has more chances of succeeding in a trial and error series.

It is interesting to note, also, that domestication tends to reduce this disparity between the sexes. It suggests the very live question whether civilization, which is a kind of domestication, operates similarly with the human species. Popular opinion seems to lean towards the affirmative; and we find expression of this movement of the social mind in the tendency to identify the aims, conquests, and education of the sexes. On the other hand anthropologists recognize a progressive differentiation of the sex types, physiologically and biologically. Possibly a point in development has been reached where psychological development has attained a greater freedom than heretofore from physiological and biological determinants.

But to return from this digression. The male (m) showed the influence of the previous experience not only in the reduction of time and errors, but also manifestly by avoiding several errors and by hesitation at certain points. He even returned to the cage without any mistakes. In some parts of the maze the movement had some definiteness, but generally had a groping appearance. This in itself is significant, suggesting that already he passed beyond the stage of purely accidental selection, that he had already acquired some kind of recognition, however vague, of rights and wrongs. The selection of paths begins to be purposive. In the four succeeding trials, in which this rat was a subject, there was observable a constant increase in the purposiveness of the movements. This takes the form of definiteness and speed where no error was possible, and of doubt and indecision where there was choice of path. The indecision tended to fade away, but did not disappear completely in this (too) brief series.

If the matter were illustrated graphically by curves, we should have the curve of speed and definiteness beginning with a maximum of slowness and complete indefiniteness, and sweeping down gradually to relatively perfect definiteness and a minimum of time. The curve of choice, on the contrary, would begin very low, rise gradually as the recognition of critical points became more acute, and would then fall gradually as the right association became habitual.

As further illustrative of this increasing purposiveness I note from the records the following pertinent observations. In Exp. 4, "one could not fail to see that the rat was trying to select his path—there seemed to be some kind of an image in his mind that he was trying to follow. The first time he came to 4 he hesitated, then went wrong; each succeeding time he seemed to recognize this place, for he went by confidently.

Indeed after the first time around he seemed sure of his path beyond this point, and at *s* visibly accelerated his pace each time." In Exp. 5, he made fewer errors, and recoiled more quickly from an error when made. Movements were all rapid, yet cautious. Again made "the error at *4*, and again quickened his pace as he passed it the second time. This acceleration was accompanied by a flick of the tail and a general abandon that said, 'I've struck the right trail.'" The movements in Exp. 6 "were purposive. He apparently knew when he was on the right and when on the wrong road. The right (latter) half of the maze seemed better in mind than the left; before reaching *m* the movements were cautious and uncertain—several mistakes—but beyond *m*, they were rapid and secure—no mistakes." Exp. 7 gave similar results.[1] There is little reason to doubt that a few more trials would have enabled him to learn the way perfectly as did the white rats in many later experiments.

The time and error factors of the five experiments, which were accurately recorded, were as follows:[2] III—15, 8′. IV—10, 2′. V—1¾, 4′. VI—3, 4′. VII—⅚, 3′. It will be seen that the relative decrease in time is more nearly constant than that in number of errors—*e. g.*, Exp. *4*, which required 10 m., gave only 2 errors; Exp. 7, requiring only 50 seconds, gave 3 errors. Probably the small number of errors in Exp. *4* is largely accidental. There is doubtless a somewhat constant relation between knowledge of the path (indicated by relative number of errors) and the time required to traverse it. It must be remembered, however, that organic conditions vary so as to make this relation practically indemonstrable.

In this series of experiments, the writer failed to observe any thing that would indicate that the sense of smell played an important rôle in the process of solving the problem, at least so far as following a trail is concerned. In no case could I make out that the male followed his own latest track or the females followed the track of the male, which often would have led them almost directly to the goal. All later experiments confirmed this view. The evidence is given in detail in its proper place *infra*.

It should be remarked, also, that the females gave no evidence of intelligently following the male, when by doing so they might have gone directly to C. The rats passed and repassed each other, each going his or her own way. Occasionally one would be deflected from his path to follow another, but seldom for any considerable distance. This same independence was observed

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[1] Reason for discontinuance was death of the rat—disease unknown.
[2] Roman numerals indicate the experiment number; the plain Arabic, the time in minutes; the accented Arabic, the number of errors.

in all later experiments, so that I think imitation even in its simplest form[1] cuts a very insignificant figure in this matter.

One other matter of interest is the general conduct of the rats in the maze. I have spoken already of the initial timidity. The manner soon became more confident, affective tension was relaxed, and curiosity and the play instinct were unloosed. In Exp. *3*, after the rat[2] had eaten and drunk a little, he seemed to become thoroughly happy, and, for the nonce, quite oblivious of the world of traps and snares. He alternately ate, drank, and ran curiously about the maze, investigating all the passages in a sprightly and eager manner. In Exp. *4*, I note "the restless curiosity they all manifest after the first pangs of hunger are appeased, carefully exploring all the passages, feeling and sniffing along the sides and tops and into all the angles and corners. Their conduct impresses one strongly as being the expression of a free curiosity—a fundamental and irreducible desire to know all this new environment. It has not at all the appearance of a further search for food, but rather a seeking for the feeling of security and at-homeness attendant upon knowledge of surroundings.

I pass on now to describe in detail Series II, with white rats.

Exp. 1. A. 13 m. *A* came out of cage 2 m. after the door was opened. A few steps into *1*—turned and forward to *b*—back, end of *1* —into cage—end of *1*—to end of *2* without pause—into *3*, half to end—turned and forward to *4*—a few steps into *4*—turned, foward to *6*—a pause, then to end of *6*—out and back, via *4*, *n*, *k*, *x*, as far as *c*. A slight pause, then forward to end of *2* again—out, and a few steps into *3*—back and thence to *h*, pausing a moment at *e* to sniff and dig—back to *e*—forward continuously to end of *7* (very slowly by *4*, as if having some recognition of the place, sniffing cautiously from side to side of gallery)—back to *6*—thence forward to C.

Rat *B* up to this time had made little progress. *A* soon came out of C, and for 15 m. the two rats ran about the maze, most of the time in the circuit immediately around the center, *i. e.*, *z-h-x-k-n*, fagging back and forth, digging at the base of the wall and biting at the wires—the depth of stupidity, one would say. *B* reached C 15 m. later, and *A*, a second time, a minute later than *B*.

It is well briefly to notice the points of interest presented in this first experiment. (1) In regard to timidity they presented a contrast with the wild rats of the preceding series. They spent little or no time looking and listening. Their movements were free and unconstrained. (2) Their movements were a trifle less vigorous than those of the brown male. They go about the business more deliberately; their movements appear less automatic. (3) At the turns in the road, the rats frequently stopped, as if in doubt which way to go. (4) The meaning of the sudden stops and turns is not very intelligible. A rat going at a good pace through an unobstructed gallery may stop suddenly or wheel about and go in the opposite direction. This indecisiveness is a constant trait of the rat character, as had been remarked in all my preceding observations and experiments. Other than this

[1] *Amer. Jour. Psy.*, Vol. XI, No. 2, p. 162.

[2] I refer solely to the male in these illustrative examples.

flightiness or unstable attention, no explanation of these movements offers itself. I do not regard this as ultimate; but for the present, at least, it must serve, as the conditions of attention are not apparent. (5) The fortuitousness of the first success is evident. The great number of errors, the repetition of the same errors, the marching and countermarching, and the general appearance of *lostness* amounted to a demonstration of the accidental nature of this first success. (6) It appears also that the very first experience was little profited by. It was noted that *A*, in course of his first wandering journey to C, did seem vaguely to recognize the locality of *4* when he approached it the second time—his slow and cautious movements seeming to indicate that—and there was a suspicion of a similar recognition at 3; but these were the only suggestions of having 'profited by experience,' and after leaving C, *A* wandered just as blindly as *B*, when trying to return.

Most of these points will come up for consideration in the fuller discussion later on.

Exp. 2. *A*, 3 m. The two rats kept together until *a'*, having gone to the end of *1*, but having avoided *2* and *3*. *B* paused to pick up a crumb. *A*, forward without pausing, by direct path, *i. e.*, *x-m*, to end of *6*—turned instantly and went like a flash to *7*—thence more slowly to C, pausing but once (to eat a crumb) on the way. *B*, after eating his crumb, went forward slowly and carefully to end of *6*. He looked as though he were following *A's* trail by scent. Here an insane suggestion seemed to grip him (there was no external occasion for fright); he wheeled, made a wild rush, and bit up at *h*. He then ran about foolishly for 15 m, twice going again to the end of *6*. The last time, he flashed out much as *A* had done, not pausing until *r*—thence slowly, as if following a trail. At *s*, *A* and *B* met, stopped a minute to play, then each went his own way, *B* still appearing to follow the trail.

In this second experiment the noticeable things are the immense improvement shown by *A*, and the appearance of "trailing" by *B*. Three possible explanations of *A's* improvement suggest themselves: (1) the right path is selected by sense of smell; (2) by lucky accident; (3) the path is identified by other means than smell. A fourth explanation might be one that included these three as variable factors. I defer discussion of this point, merely indicating that I do not regard the first factor (smell) as important, in spite of the presupposition in its favor, and apparent following of the trail by *B*, noted above.

Exp. 3. *A*, 4 m. Distraction on part of the rat prevented a full record. The time of actual performance was not more than 1½ m. For the other 2½ m., *A's* attention was directed to a foreign matter. On the whole, however, he showed more familiarity with the path, making fewer pauses, and moving more rapidly and securely.

Exp. 4. *A*, 1¾ m. *B*, a few seconds longer. *A's* course: End of *1*—forward quickly and into *2*—stopped at last turn and back, seeming to recognize his error here—paused at *3*, then to end of that *cul de sac*—turned instantly, and ran swiftly and continuously to *4*—entered *4*, going slowly around circuit *n*, *k*, *x*—paused meditatively at *x*—then suddenly started on a quick gallop, accelerating at *m* and *4*, and not pausing till he reached C. *B* followed about the same course, but went less quickly. He showed less the appearance of "trailing." In the case of both rats, something very like disgust was manifest when they found themselves at the end of a blind alley. The instant recoil, the swift retracing of their steps, and the decisiveness with which they turned from the blind alley into the right path, seldom going *back* now beyond the entrance to the *cul de sac*, seemed to indicate something more of mental content than the mere recognition of the impossibility of get-

ting further that way. Another noticeable fact was the increased security and confidence of all their movements. The slow, blundering *modus operandi* of the first experiment had given place to rapid, definite, purposive movements. This was evident alike in respect to the right moves and in connection with the errors. It has been noted already that the errors were retraced with great rapidity. It remains to remark that in nearly all cases, the entrance into the blind alleys was marked by hesitation, and the journey to the end was made slowly and doubtfully. It was also noted in passing that *A*, after passing *x* the second time accelerated his pace, and increased the acceleration at *m* and *4*, indicating thus a greatly increased familiarity with the path from *x* on.

Exp. 5. *B*, 1 m. *A*, 1½ m. Started together. Omitted *1* for the first time. At *2*, separated, *A* entering *2*, *B* going on after a momentary pause. *B* entered *3*—proceeded only a few steps—turned confidently—out and forward to *n*. Delayed here and was overtaken by *A*.[1] Both remained here a little: *B* first recovered his wits, and suddenly dashed back through *4*, and forward to C. Less than 10 sec. from *n* to C; and went with full assurance, hesitating at no point. The appearance of the action was as if some kind of an image of the path to C had flashed in upon the creature's mind touching of simultaneously the motor discharge. At this point I do not wish to discuss the possible nature of the process involved further than to say that the term image does not mean here visual image. Representation, perhaps, would be a less objectionable term to describe this hypothetical mental correlative of the action.

In this experiment *B* for the first time equalled *A's* performance. In all the former tests, both with this apparatus and with that of preceding experiments (*Am. Jour. Psy.*, Vol. XI, No. 2, p. 156 ff.), he had shown a slight inferiority. In the succeeding experiments he was generally first to *C*, though there was slight difference.[2]

Exp. 6. *A*, 1½ m. A variation introduced. The entrance into the center, C was barred by Exp. Box II (*Loc. cit.* above) used in a former series of experiments with these rats. The door of this box, which was held closed by strips of paper pasted upon the door and the sill, was opened inward by a spring when the papers were removed. Food inside the box. The reappearance of this problem so unexpectedly and under such different circumstances after the lapse of 27 days constituted an interesting test of the permanence and distinctness of the memory.[3]

B first out. Directly to *2*, pause—a very human-like indecision. After 5 or 6 abortive starts each way, finally entered *2* and proceeded slowly to end. Turned and swiftly retraced his steps. At mouth of *2* joined by *A*. Together they proceeded placidly to end of *3*. Turned instantly and galloped back swiftly out of *3*, not slowing up until *e*. Here *B* charmed by the odor from C stopped to dig. *A*, forward soberly, hesitated at *x* turning now right, now left, but finally on to *n*.

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[1] Apropos of the possible rôle played by smell in selecting the path, it is significant that *A*, after following the path traversed by *B* from 3 to 5, *here* diverged, turning into *5* before going to *n*.

[2] Later in this same experiment I observed a striking instance of the difference between the affective character of these rats and of their wild brothers. The laboratory cat jumped upon the maze and showed a friendly interest in the rats. They were startled at first, but soon were trying to bite her toes through the meshes. Under the same circumstances, the wild rats were stiff with terror for 15 minutes.

[3] The term memory is used in this paper in its generic sense. In the present instance it implies: in the presence of accustomed conditions, a mental state leading to the performance of the task incident to the situation. [illegible] and distinct recall;" much less, reference of the repr[illegible] the subject's experience. Nor does it imply self-cons[illegible] ing of recognition—'at-homeness.' The phrase 'p[illegible] be used, but that this recognition-element is not pr[illegible]

He delayed there a moment—then hastened on to C, via *4*, without further delay or mistake. (*B*, reached *n* before *A* left, but seemed to 'lose his head'—ran back to *e*—to *n* again—then *5*—reached C more than a minute after *A*.) When *A* came to the barricading door of the box, he attacked the paper without hesitation, almost automatically. After pulling off the first paper, he ran back a little way in the characteristic half-frightened manner of the rat, but returned immediately and removed the other paper. All accomplished in a few seconds. The memory was perfect.

This experiment illustrated also the fact of the increasingly definite recognition of critical points, as evidenced by the hesitation and indecision at those points. This was decidedly more striking than in the preceding experiments, especially in the case of *B* at the entrance of *2*, where, as stated, he exhibited a quite human hesitation, turning now one way, now another. The conduct of *A*, at *x*, was hardly less noticeable. *B's* hesitation continued all the way to the end of *2*, as indicated by his slow and doubtful progress; and his disgust when he reached the end, was as manifest as had been his indecision at the beginning.

The rats were exceedingly active during the evening, traversing curiously all the galleries of the maze, investigating every angle and nook; and returning frequently to C for a drink of milk—they had carried the bread out into the maze at once. As an illustration of the rapidity and accuracy of their movements, I saw both rats go from *n* to C without a suspicion of a pause in less than 5 seconds. The distance is approximately 16 ft. The path includes 16 right angles and 4 chances for error.[1]

Exp. 7. *B*, 3 m. Slow in starting. *B* went to end of *1*—then slowly forward as if feeling his way—eliminated errors *2* and *3*, hesitating only slightly—blundered at *x*, going to *n*. After running back and to between *n* and *k* for a moment, he passed on *via x*, *m*, etc., to C, without further hesitation or error. Tore off the papers instantly on reaching C. Memory on this point quite as perfect as *A's*. After taking a drink of milk, *B* seized a piece of bread and started back—paused at *h* to eat—met here by *A*, and hastened on to *c*—stopped again to eat. *A* followed here in a few moments, and *B* went to the cage. Almost immediately he went again to C and brought back the other piece of bread. The rats ate their supper in the cage, making frequent trips to C for milk. *B* made the journey twice very swiftly without error or delay; and both of them, several times with but one error. They take a run to C for a drink as naturally as they would turn around, or as a man would go out between the acts. The ease of it all indicates a pretty definite knowledge of the way through the maze, as well as of the hedonistic end to be attained by traversing that path.

Exp. 8. *B*, 30 sec. *B* made the journey with only one error—went half to end of *1*—and without indecision at any point. (He paused 6 or 7 seconds at one point, but because his attention was caught by something outside of the maze). Tore off the papers instantly. The total time between entering the maze and entering the box was just 30 sec. Deducting the time of the pause (above noted) and that for pulling off the papers—about 5 sec.—we find the actual time in traversing the maze less than 20 sec. This rapidity of movement illustrates—measures roughly—the almost automatic definiteness of the mental pro-

[1] The next morning, I found the rats had carefully deposited the remnants of bread and the *bits of paper* in their cage. A few days later, after I had given them abundant excelsior for a bed, they ceased to save the bits of paper from the box. The collecting impulse seems to be inhibited by the feeling *enough-at-home*.

cess—not quite automatic, as appears from the fact that the animal will again make mistakes and show indecision at critical points. The movements are habitual but not secondary automatic. Attention and discrimination are not wholly shelved. *A* was a few seconds later. Both went back to the cage with their bread without mistake. In making another trip to C a few seconds later, *A* went right to *4*; here hesitated as if "scratching his head," then entered this gallery slowly and doubtfully—only a few steps however; then with a sudden turn and a triumphant flick of his tail he returned to the correct path. This is peculiarly interesting from the fact that he made this error complete, the first time, going completely around the circuit *4*, *n*, *k*, *x*, *m*. I watched *A* make two more journeys to C. The fourth time he did not pause or hesitate or slacken his pace at *4*. As in Exp. 7, frequent journeys were made to C for milk. These averaged one every 4 or 5 minutes during the half hour I watched. They were made generally without error and in as brief time as 15 or 20 sec.

After the edge of the appetite is worn off a little, the rats tend to let loose the play instinct in the fullest degree. In all their journeys they 'play by the way,' strolling nonchalantly into the blind alleys, now sniffing listlessly, now with half-eager curiosity in all the corners, and angles. That they *know* their way pretty well, however, is evident from the manner in which they take a sudden start from any place in the maze and 'flash' to the end—either end. To one who is familiar with the ways of the white rat, or who is able to imagine his action from the descriptions and figures above, the term 'flash' in this connection will be appreciated as realistically literal.

Exp. 9. B, 1 m. (Exp. Box II not used). Each rat made 2 errors: both entered *1*; *A* took long way at *x*—*i. e.*, *k*, *n*, *4*—*B* turned into *4*, went as far as *n*, then retraced his steps. It is noteworthy that these are the most persistent errors. Neither rat hesitated at *2* or *3*. It is not apparent why the error at *1* is so persistent—it was fully eliminated only once. The persistence of the errors at *x* and *4* is a simpler matter. A glance at the diagram will show that these mistakes may be rectified without a return—indeed they are not, properly speaking, mistakes at all, but rather failures to select the shorter path. In each case the rat has but to push ahead in order to recover the right trail. It is probable that these errors would be fully reduced with a sufficient number of trials—in fact other series of experiments confirm this view, though, as will be seen, they are the last errors to be sloughed off; and, with some rats, absolute certainty is not reached in a great number of trials. In one case, forty did not suffice.

The series really concludes with this experiment, the tenth serving merely to test the memory of the maze experience. It adds little or nothing to the data for explaining the formation of the associative nexus, and the mental material and powers involved in that process.

It was made 22 days after Exp. 9. The results were: *B* reached C in about two m., making errors at *1*, *2*, and *3*; *A*, a few seconds later, errors at *1*, *3* and *x*. They clearly recognized the maze, but some of the details had slipped away. *B* hesitated at both *2* and *3*, as did *A* at *3* and *x*, showing that there was recognition of these critical points, but that the memory was indistinct. After returning from *3*, *B* proceeded more securely—his gait had been slow and doubtful before—hesitating only at *x* and but a second there.

The same experiment in several other cases gave similar results—a constant tendency towards a partial lapse of the association.

Analyses of Results.

In appreciating the results of this series of experiments,

about the same facts come into view, only more distinctly, as in the case of the wild gray rats; the initial indefiniteness of movement and the fortuitousness of success; the just observable profit from the first experiences; the gradually increasing certainty of knowledge indicated by increase of speed and definiteness, and the recognition of critical points indicated by hesitation and indecision; the lack of imitation and the improbability of following by scent; the outbreak of the instincts of play and curiosity after the edge of appetite is dulled. In addition are to be noted the further observations upon the contrast between the slow and cautious entrance into, and the rapid exit from the blind alleys, after the first few trials; the appearance of disgust on reaching the end of a blind alley; the clear indication of centrally excited sensation (images) of some kind; memory (as I have used the term); the persistence of certain errors; and the almost automatic character of the movements in the later experiments. Viewed objectively, these observations all converge towards one central consideration; the continuous and rapid improvement of the rats in threading the maze, amounting to almost perfect accuracy in the last experiments. No qualification of this view was found necessary in the light of many later experiments. Rather they all confirm it. The mental aspect is considerably more complex, the mental factors, much more difficult of analysis and evaluation; but the central fact in the process seems to be the recognition by the rats of particular parts of the maze. Deferring consideration of this side of the matter, and looking now only at the objective side the important points are, as in case of the wild rats: (1) the increase in speed, and (2) the decrease in the number of errors and in uncertainty. Comparison of the two points is as follows:[1] I-13, 13′. II-3, 2′. III-4, —. IV-1¾, 4′. V-1, 2′. VI-1½, 3′. VII-3, 2′. VIII-½, 1′. IX-1, 2′. (X-2, 2′). As with the wild rats, we find a fairly constant decrease in time and in number of errors. Similarly, there are fluctuations both in time and number of errors, *e. g.*, Exp. 9 shows an increase over Exp. 8 in both respects. This is to be expected from the character of the animal and the confessed impossibility of completely controlling even the external conditions, not to mention the particular internal conditions in each case. Allowing for such variable factors, the relative time required and number of mistakes made furnish a fairly accurate index of the progressive acquaintance of the rats with the problem. The contrast between the first slow, blundering, accidental success and the definitely foreseen success of Exp. 8 (taken as the best) is striking. This is brought out even more saliently by the

[1] Significance of the numerals is the same as *supra*.

graphic representation on p. 201 than by the figures collocated above. The solid line indicates the course followed in Exp. 1; the dotted line that followed in Exp. 8.[1] The arrows mark the point where the rat stopped and turned about, and are pointed in the direction he was headed when he stopped. The dots (•) indicate points where considerable pauses were made. The arrow and dot between *4* and *m* indicate that the rat, when returning from an abortive essay into *4*, went as far as that arrow, paused, then turned and went forward.

Turning now for a brief consideration of the relative results of experiments with the two kinds of rats, some interesting and rather unexpected facts crop out. Comparison of the time and error tables of the two series discloses no considerable superiority on either side, although in this comparison I disregarded entirely the first two experiments of Series I, comparing the 5 trials recorded of Series I with the first 5 of Series II. The average of times required and errors made gives the white rats the advantage in regard to time; the brown rats, in regard to errors.[2] In view of the handicap of two experiments, it will be seen that the advantage lies with the white rats throughout. The brown rats had gained comparatively little from the first two experiments, imperfectly conditioned to be sure, but in which they had the usual freedom of the maze during the entire night. I am of the opinion that even if the conditions of experiment had been identical, the balance still would have tipped in favor of the white rats, so potent is the inhibitive influence of fear with the wild rats. The rational conclusion seems to be that there is little difference between the two in actual intelligence. The wild rat is somewhat more vigorous and active, and consequently this excess of activity increases his chances of accidentally hitting upon the right path. This might secure him a slight advantage *in time* in perfecting his knowledge of the path. It would not signify, however, any advantage in quality or degree of intelligence. It might
a larger number of associations (supposing a free life
nimals) but would not make any difference with their
complexity. In short, the results of superior activity
elligence, though they seem often not to be discrim-
ccounts of human as well as animal doings. This
tivity, however, is fully balanced by the wild rats'
ceptibility to fear under these strange conditions.

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gives the record of Rat *A* and Exp. 8, of Rat *B* is in-
The attainments of the two were practically equal.
s marked on a diagram at the time of observation.)
e: Series I, 5 m. 19 s.; Series II, 4 m. 33 s. Average of
4 1-5; Series II, 5 1-5. In Exp. 3 of Series II, I was
r there were 4 or 5 errors. The maximum is taken.

In ability to profit by experience—in this case, to learn a definite route involving possibilities of frequent error—the two are not far different.

This conclusion does not tally very well with the general opinion that animals suffer mental deterioration under domestication. However that may be with other animals, it evidently is doubtful in this instance. The white rat in comparison with his wild congener is somewhat less vigorous and hardy (especially does not endure cold or hunger so well), and has sloughed off some of the timidity and suspiciousness of the wild rat; on the other hand, his senses with the exception of sight are as keen, his characteristic rat traits are as persistent, and his mental adaptability is as considerable. The *modus operandi* of the two kinds in the maze shows little variation. Likewise there is no difference in the curiosity manifested, either in kind or degree. In view of the many generations of luxurious idleness [1] of the white rat, this profound and enduring nature of specific psychic traits is striking. A pertinent illustration was furnished by a young rat that escaped from his cage and was loose about the laboratory for several days. He had just been weaned when the accident occurred. Food was rather scarce and he got pretty hungry. Finally one morning he found his way into the chicken pen, and in less than two minutes had killed two chickens, and was upon a third when discovered. The chickens were three times as large as himself. The killing was done by biting through the throat of the victim, and was as neatly and deftly executed as if the executioner were an old hand. The importance of this illustration lies in the fact, that this is exactly the method of killing employed by the wild rats. The only possible preparation in his own experience this pigmy could have had for such serious business must have been in play with his fellows. That, however, was general rather than specific; and, at best, was of slight importance, as he had reached the playing age but few days before. Another typical illustration of the persistence of specific traits is furnished by a perfectly tame pet rat that exhibited the greatest fondness for a hole in the base-board of a room where he was allowed to run, making for the hole every time he was set free in the room, and dodging in and out at every sound; yet so tame that he would come out and allow himself to be caught as often as I went to the hole and called. Such cases give some suggestion of the tenacity of those fundamental specific traits which "persist with undiminished vigor" long after the conditions of life which

[1] I cannot find that the white rat is known to exist in the wild state. There is a tradition that it was brought to the Occident from an immemorial existence in China. I am not able to verify this tradition—or disprove it.

called them into being have changed radically. In these cases non-use certainly has had but little effect in reducing the potential force of specific instincts.

What is true of such relatively superficial specific traits is doubly true of generic instinct-feelings. Curiosity is a good example, frequently coming into evidence as it does in these experiments. Its intensity is not diminished with the long domesticated white rats. Nor is it greatly changed. Ribot, rightly regards curiosity as the basis of the 'intellectual sentiment.' "This primitive craving—the craving for knowledge—under its instinctive form is called curiosity. It exists in all degrees, from the animal which touches or smells an unknown object, to the all-examining, all-embracing scrutiny of a Gœthe; it always remains identical with itself."[1] I am persuaded that Ribot is right in regarding this affection as primitive and as a primitive craving for knowledge; not merely a reaction to hunger or sex stimulus. The desire for familiar acquaintance with environment, concomitant with fear and uneasiness in strange surroundings, is about as fundamental as hunger. Observers of wild animals in their native haunts tell the same tale. The astronomer who orients himself with respect to infinite worlds satisfies the same craving for knowledge and calms the same uneasiness in strangeness as does the animal which seeks all the knowledge possible to him of his universe. The reduction of chaos to cosmos begins there.

Such considerations as these suggest the question whether zoölogical psychology may not profitably turn from its almost exclusive search for variation, to a search for the relatively invariable factors in the animal mind. In order to do this the ideals of structural psychology must be departed from somewhat, and attention directed to the study of the instinctive traits and tendencies, out of which, in higher differentiations, human nature is made. From the point of view of psychic statics these are composite and analyzable; but, from the point of view of psychic dynamics, they are themselves primitive and elementary. By this method, if by any, will be gathered the material for a natural history of mind. From this source light may be expected upon many obscure problems in individual and anthropological psychology.

General Form of Animal Intelligence.

The amount and variety of fact brought out in the preceding scription and analysis must serve as excuse for this somewhat lious presentation of details. It justifies the initial assump- n that the results of such a study as this are qualitative

[1] ibot: Psy. of Emotions. (Eng. Tr.) p. 368.

rather than quantitative; and that a generalized statement of results or any graphic representation whatever of the data by curves, would indicate only the most general form or tendency of animal intelligence, which was decidedly less what I wished to exhibit than the details of the performance. My conviction of the importance of this aspect of the case is strengthened by M. Hachet-Souplet's brilliant suggestion of a new method of classification of species from the psychological point of view.[1] M. Hachet-Souplet shows clearly that there is very good reason for cutting loose from the trammels of morphological classification in our psychological investigations of animals. If, however, such a desideratum is to be realized, it must be by studying the mentality of the different kinds of animals with the same minuteness that morphology employs in its domain.

A few words, however, as to the 'general form of animal intelligence' and a more adequate appreciation of the value and limitations of the 'curve' in connection with the same may not be *mal apropos.* In a former paper,[2] I have noted that a time curve would be an insufficient index of the definiteness and certainty of an animal's mental processes, on account of the inconstancy of internal conditions. In this paper I have pointed out that a more adequate representation might be made (at least for these experiments) by compounding the time and error curves, and also a curve representing the indecision at critical points—if such could be extracted. Such a compound curve, however, would still be far from telling the tale fully and precisely.

The one extensive and important study in comparative psychology in which the graphic method of presenting results is largely employed is that of Dr. Edward Thorndike upon cats, dogs, and chickens.[3] Dr. Thorndike's methods with his cats and dogs was to confine the hungry animals in boxes, small enough to be uncomfortable, from which they might escape by "some simple act, such as pulling at a loop of cord, pressing a lever, or stepping on a platform." Food was exhibited outside

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[1] P. Hachet-Souplet: Examen psychologique des animaux, Paris, 1900. Schleicher Frères.

[2] *Am. Jour. Psy.*, Vol. XI, No. 2, p. 136.

[3] Edward Thorndike: Animal Intelligence. Psy. Rev. Monograph, Vol. II, No. 4, June, 1898. Dr. Thorndike's methods have been criticised by: W. Mills (Psy. Rev., May, 1899); C. Lloyd Morgan (Nature, July 14, 1898); and Kline (*Am. Jour. Psy.*, Vol. X, Nos. 1, 2, 3). Kline's criticisms are fragmentary, but valuable. Morgan's Review in Nature is discriminating and sympathetic. Mills raises some objections to Dr. Thordike's work, but is blinded at times to the other's meaning by his polemical ardor. Thorndike has replied to Mills (Psy. Rev., July, 1899).

the enclosure as a special incitement to vigorous effort; and escape was rewarded with the food. The time required to escape in successive experiments was recorded, and the results represented by curves. These time curves are regarded by Dr. Thorndike as exact indices of the progress of the animal in the formation of the required associations. Though these temporal data do not seem so significant to me, as to Dr. Thorndike, for the reasons given above, yet they do exhibit, I think, what I have called the general form of animal intelligence; or as Professor Morgan expresses it in an analysis of Dr. Thorndike's paper (v. note above), "they bear out the contention that the method of animal intelligence is to profit by chance experience, and depends upon the gradual establishment of direct associations." I suppose Höffding means essentially the same thing when he says: "The simple primitive consciousness does not feel the need of concepts but goes passive from disappointment to disappointment." Professor Morgan reports in the same paper, having attempted to extract from some of Mr. Thorndike's carefully plotted data, a mean curve for the method of trial and error. The attempt was not very successful he admits; but he thinks the resultant curve does indicate the gradualness of the process which theoretically would be expected. On the whole, this conclusion seems to me essentially sound. At least, my own observations with rats, under what seem to me more natural, and sympathetic conditions, give confirmatory results. I have plotted tentatively a number of time curves, both from the results of my experiments with the maze and with other devices; and they show no radical variation from the general form of Dr. Thorndike's curves. I think Morgan is right in asserting that "the form of his curves affords no particle of evidenee for reasoned behavior." No more do mine. It must be remembered that Morgan rigidly limits the term reasoning or rational procedure to the process of drawing logical inference. The relation between experiences must be perceived as such. The transitive moment between focal points in consciousness must itself be capable of becoming focal. The reasoning creature must be able to 'focus the therefore, think the why.'[1] In the broader sense of practical adaptation to varying conditions by direct ssociation; or as Binet[2] defines it: "an organization of images termined by the properties of the images themselves, so that e images have merely to be brought together for them to beme organized, and reasoning follow with the inevitable necesty of a reflex"—Morgan readily admits reasoning in animals.

Morgan: Comparative Psychology. *In locis.*
Psychology of Reasoning. (Eng. Tr., p. 3.)

Morgan further made a comparison of his mean trial and error curve, with a mean curve of rational procedure, which he plotted from Dr. Lindley's data compiled in his "Study of Puzzles." (*Am. Jour. Psy.*, Vol. VIII, No. 4.) These present a clear contrast, he thinks. In the latter case he finds "a sudden leap from failure to success when the trick of the puzzle was discovered and understood;" as opposed to a "gradual sweep towards rapid and assured success" with the former.

There is one fact, however, in connection with the trial and error curves that Morgan does not remark. Nearly all of Dr. Thorndike's curves show a sudden fall after the first success. My own experiments with various devices gave similar results. This fall is analogous with the fall in the curve of rational procedure after the 'trick was understood.' This fact does not affect the distinction between the two processes. The sudden fall in the trial and error curve indicates only effectiveness for reproduction of the first right association. In this method, learning the trick or the task, depends in the first instance upon performing it fortuitously so far as previsioned end is concerned; and requires then time and repetition for perfecting the knowledge. Improvement depends upon memory of previous performances, or forgetting useless details. The relation of the acts does not become focal. On the other hand, in rational procedure, the trick may be understood before it is performed. The entire plan of solution may be envisaged before a move is made. As a matter of fact, however, in the great majority of cases tested by Dr. Lindley, in which rational procedure was employed, the understanding at the beginning was only partial, the plan was vague and hazy. The understanding became full and definite through abortive attempts at practical solution. The younger children, Dr. Lindley found, as would be expected, used almost exclusively the trial and error method, chance success and direct association. With older children rational procedure based upon a considered plan came progressively into evidence. "The younger children succeed through a long series of slight variations. Occasional lapses into useless movements occur; but the trend is by a slow and primitive method of exclusion towards the goal." Among older persons the inhibitive influence of failure is stronger. The memory of the failure takes its place as a substantive element in consciousness and constrains the subject to reconsider, to deliberate. The variations, too, are wider and more far-reaching, indicating a larger and more complex grasp of attention. Yet comparatively few, even of adults, pursue a strictly rational procedure. The close similarity between animals and children is obvious.

The fact that the trial and error method plays so large a part in human mentality, and especially that it predominates with

children, still further supports the view taken in the beginning of this paper that animal intelligence works almost exclusively by this method. Although this hypothesis was assumed for the present case only, it certainly covers adequately a very large part of animal activity. Most anecdotal cases of animal reasoning are explainable upon this ground. So far as the narrowly experimental studies of animals go, they point in the same direction. As yet, however, these are too limited in number and too restricted in scope to be very conclusive.

On the other hand, however, there is yet something to be said. The analogy between children and animals is so close that the manifestation of reason in some very young children suggests that some animals may have the same power. Preyer cites the case of a two-year-old child getting a cricket and standing upon it in order to reach a desired object.[1] M. Hachet-Souplet[2] shows wide variations of psychic faculty among animals of closely related morphological groups. Individual variations, too, are indubitable. M. Hachet-Souplet has no doubt that some animals reason. His opinion is important since he is an experimenter in a large and fruitful way, and is at the same time in the main sharply critical of his facts. He describes a striking case of reasoning in a coati, as follows: "Un de nos amis nous ayant rapporté un merveilleux trait d'intelligence de la part d'un coati, nous avons résolu de provoquer artificiellement autour d'un autre coati, des circonstances analogue à celles dans lesquelles le premier s'était trouvé, quand il donna une si grande preuve de sagacité. On sait que l'espèce est très friande d'œufs de poule; nous en plaçâmes un sur une haute cheminée de façon à ce qu'l pût être vu du coati et, après avoir éloigné légèrement les sièges, nous quittâmes la pièce; en nous arrangeant toutefois de manière à ne rien perdre de ce que ferait notre sujet.

"Il s'agita d'abord, saute deux ou trois fois; mais, voyant que son élan ne le portait qu'à mi-hauteur de la tablette, il semblait réfléchir un instant. Il se dirigea ensuite vers une chaise en chêne ciré qu'il essaya d'attirer du côté de la cheminée, mais ses pattes glissait sur le bois et il renonça à son enterprise; il semblait désespéré. Cependant il aperçut dans un coin un paquet de vieux chiffon et parut frappé d'une véritable *idée. Ayant pris une des bandelettes, il en entoura le pied de la chaise et il se mit à l'attirer à reculons.* Quand le siège fut contre la cheminée, en deux bonds, mon coati monta sur celle-ci et s'empara de l'œuf." Manifestly the coati in this case perceives relations, more complicated relations, indeed, than the

[1] Preyer: Infant Mind. (Eng. Tr., p. 185.)
[2] *Loc. cit.*

relation perceived by the child cited above. Such a mental expression goes beyond the explanatory possibilities of 'direct association by trial and error methods.'

Perhaps the real question after all is not whether animals perceive relations, but, rather, *what animals perceive what kind of relations.* This would seem to be the logic of M. Hachet-Souplet's position; and, what is more important, it is the logical method of psychogenetic study. Granting that animals may perceive relations, we have, then, definite and feasible problems to investigate: the kind and complexity of the relations perceived. This method should give data for a better understanding of the nature of animal reasoning,[1] judgment, inference, and the consciousness attending these processes. It would not be surprising if degrees of complication and of symbolism were found to constitute the differentiæ.

On the whole, the modern studies of comparative psychology confirm Hume's acute observations on the nature of animal intelligence. "Animals, as well as men, learn many things from experience, and infer that the same events will always follow the same causes. By this principle they become acquainted with the more obvious properties of external objects, and gradually, from their birth, treasure up a knowledge of the nature of fire, water, earth, stones, heights, depths, etc., and of the effects which result from their operation. The ignorance and inexperience of the young are here plainly distinguishable from the cunning and sagacity of the old who have learned from long experience to avoid what hurt them, and to pursue what gave ease or pleasure. . . . An old greyhound will trust the more fatiguing part of a chase to the younger, and will place himself so as to meet the hare in her doubles; *nor are the conjectures which he forms on this occasion founded in anything but his observation and experience.* Animals, therefore, are not guided in these inferences by reasoning, neither are children, neither are the generality of mankind in their ordinary actions and conclusions, neither are the philosophers themselves. Animals undoubtedly owe a large part of their knowledge to what we call instinct. *But the experimental reasoning itself, which we possess in common with beasts is nothing but a species of instinct or mechanical power that acts in us unknown to ourselves.*" This statement of Hume's[2] as to the general form of animal intelligence has not been improved upon. His expression 'experi-

[1] Benn (Gk. Philosophers, I, p. 381,) makes the interesting suggestion that animals reason disjunctively ("after a canine fashion"). It is from the disjunctive form that all other forms of reasoning are successively evolved.

[2] Hume: An Enquiry concerning Human Understanding. Section IX, pp. 85 ff.

mental reasoning' seems to me singularly happy and accurate, guarded, as it is, by the suggestion of its subconscious character —especially happy in comparison with the clumsy expressions of some modern comparative psychologists whose abhorrence of anthropomorphism leads to the opposite extreme both in thought and expression; and causes them to inveigh against that vice *ad nauseam*. I suppose Hume would be dealt with summarily on this score by these writers. But is not a certain amount of chastened anthropomorphism a wholesome specific, a kind of saving grace against the scientific pedantry that thinks to create a new science of comparative psychology with the imperfect instruments of experiment and the law of parsimony. The law of parsimony is important, no doubt, but it may be employed too rigorously. The real difficulty lies not in the tendency to interpret animal intelligence in the terms of human experience, for we have no other way; but in the faulty and imperfect analysis of human experience. That is the real vice of Romanes' work. His analysis did not go much deeper than the discursive adult human understanding. This difficulty is intensified, not only by the fact that human consciousness is permeated, and, as it were, recreated by self-consciousness; but also by the fact, not always heeded, that the more elementary and obscure phases of human experience, as yet, have not been fully and definitely analyzed.

Another difficulty, not less real and important, but not sufficiently remarked, is found in psychophysical limitations. This difficulty is frequently met with in human psychology. Galton's Academicians who regarded mental imagery as 'moonshine' illustrate the point. They experienced no mental images; therefore, mental images did not exist. A similar limitation, Ribot thinks, leads psychologists to cavil at memory of emotions. Now, doubtless, the psychophysical disparities between man and brute are inconceivably greater than between man and man. The immensely greater rôle played by smell, for example, or motor experience, in the economy of the animal mind cannot be [illegible] appreciated. We can hardly have any idea of the radically [illegible]nt tone and feeling of such consciousness; and we cannot [illegible]h any precision what modifications of intelligent pro[illegible]re concealed from our view in this way.

The Process of Learning.

[illegible]er the process of learning the way through this maze [illegible]tely described as a gradual establishment of direct asso[illegible]w profiting by chance experience depends upon the [illegible]tached to the phrase 'profiting by chance experience.' [illegible]he remainder of this paper to attempt an analysis of [illegible] factors involved in the animal's solution of the

problem; and to offer some suggestions upon the character of the perfected knowledge.

It will be well to résumé the facts by following the rats *A* and *B* of Series II from their introduction to the maze, throughout their experience of getting acquainted with their new environment, to the time when they have perfect mastery of the situation. In their first trial, after a lapse of 13 minutes and after many errors, returns, and delays, they find their way into C. Here they are rewarded for their labors by all the pleasure possible to a rat from the satisfaction of a keen-edged appetite by a good meal of bread and milk. This first success is assumed to be accidental; its realization does not depend at all upon previsioning intelligence. The animal does not foresee the end and set to work to attain that end. There is no reflection. The determining conditions in the rat's mind are more immediate in their effect. The most obvious of these are: hunger, perception of the odor of the food, curiosity, normal activity (the obverse of curiosity) and the instinctive special trait of following out tortuous passages—a definite rat-hole consciousness that acts, as it were, thygmotactically. These factors, with the inhibitive balance-spring of timidity, firmly rooted and deeply toned emotionally, constitute the relatively stable background of consciousness over which play the lights of the perceptive and discriminative processes as the animal proceeds with the task. The rat, when he enters the maze, is psychically a confused complexus of these factors. No one of them looms high above the others in the wave of consciousness. Attention is dispersed; perhaps, better, distraction prevails. Nevertheless, 'experimental reasoning' begins at once. The animal keeps constantly moving; but his activity at this stage is evidently sensori-motor (or organo-motor). Motive in the sense of ideated end is absent. The nearest approach to this is the possible idea of a definite kind of food incident to the perception of the familiar food-odor. This is not impossible. On the other hand the effect on consciousness may be only an intensification of the hunger psychosis resulting in an increase of motor activity. However this may be it probably is the animal's instinctive fondness for following out devious ways his, thygmotactic rat-hole psychosis, rather than the smell of the food that gives determinateness to his movements at first. Were this trait less imperative, the rat, when he comes near the food (*e. g.*, at *e*) would become the victim of his hunger and his perception of the position of the food—for the food at this point could be located by smell—and would spend himself stupidly in endeavoring to force an entrance. In general, however, he soon passes on, going directly away from the Canaan of his desire.[1] Failure to get through by gnawing and digging,

[1] Occasionally one does just this stupid thing. Cases were noted in passing.

quickly results in a wavering and dispersion of attention. Concomitantly the perception of the odor relapses into the margin of consciousness, and the instinctive motor tendency at this juncture reasserts itself as the focal and directive influence.[1] The first success then may be set down as the accidental issue of a trial and error series, motivated by hunger and curiosity, mediated by the sense of smell and, more largely, by this instinctive motor trait, and consummated by the pleasure of hunger satisfied. And yet the term *accidental* must be used with reservations. The rats of this series, and of all others in their first trial, seemed to profit at once by experience. By this I mean that after they had made an error once or twice, though they had not yet succeeded in reaching C, they would hesitate or even avoid the error when going over the ground a second time. For example, rat *A* went only a few steps into *3* the second time he reached that place, and avoided *6* and *7* completely. A glance at the record of the first experiment will make this perfectly clear. Such cases may be attributed to pure chance; the conduct of the rat, his hesitation more than his avoidance of the error, indicates, rather, recognition and selection.

It will be remembered that the rats have the entire night each time for exploration of the maze. This results in remarkable improvement in the second trial. In the succeeding experiments the improvement is continuous in the elimination of errors and in the increase in definiteness and speed. The rats soon acquire a practically perfect knowledge of the maze, so that they can make the journey quickly and accurately when they want to do so, or stroll about as they list.

How explain this improvement? What does 'profiting by chance experience' mean in this instance? how is it assimilated and how utilized?

Doubtless one factor in the process is the memory of the pleasant experience at the end. In addition to the undirected and undifferentiated motive of hunger and the motor trait of the first trial, there is, in the second, a dimly ideated end which probably becomes progressively clearer in the subsequent experience. But the essential point is certainly the recognition of the critical points along the way and the discrimination of

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[1] With several subjects the odor stimulus was done away with entirely to see whether they would make the first journey to C as well as the rats that had that stimulus. No appreciable difference was shown either in time or number of errors. The rats followed out the maze to the end, C, just as perseveringly as if the food had been there dispensing its savory solicitations. The expected did happen, however, in respect to learning the direct way to C. They made little progress in five or six trials. As there was no pleasant association at the end of the journey there was nothing to determine the building up of this definite association train.

the divergent paths at these points, leading to purposive selection of the right path. The memory of the pleasant experience at the end would be of slight avail, if the rats did not recognize the critical points and discriminate and select their paths. The animal begins by going right and wrong wholly by chance. After a few trials he comes to recognize the doubtful places, and hesitates when he comes to them, undecided which way to take. The external signs of indecision vary between standing still as if trying to think which way to go, and abortive starts each way. Sometimes to these is added standing up and sniffing in the usual manner of orientation. This movement seldom was observed after the first two or three experiments, *i. e.*, after the dilemma began to be clearly felt. At this stage, the choice of path is still about as often wrong as right. The distinguishing accidentia are acquired gradually. Progress in discrimination is marked by decrease of hesitation and in more frequent choice of the right path. The path chosen often is pursued doubtfully. If the wrong one is chosen, the error frequently is retrieved after a few steps; if it is followed to the end the return is made swiftly and the right path is taken confidently. In the final stage, errors and hesitation drop out entirely. The right path is followed from start to finish without attention to specific points *en route*.

It should be noted that the learning was slowest in connection with o, x, and 4. The persistent confusion at o is attributable probably to its being at the entrance of the maze. At this point there is a maximum of affective excitement. The momentum of association has to be gathered as the animal goes along in the familiar path. In a remote way it may be likened to the stumbling and groping of an orator at the beginning of a familiar theme. The suggestion that the rats might have a penchant for right as opposed to left was found baseless by the use of the reversed maze. A definite memory of direction seems to be required. The slower discrimination at x and 4 was due doubtless to the fact that wrong choice at these points consisted in taking the roundabout, rather than the direct path. Strictly speaking there was no error. In all the other cases, taking one path was associated ultimately with success; taking the other, with failure—disappointment. In these cases the association would seem to be between path and distance.

In such cases profiting by experience manifestly involves the processes of recognition, discrimination and choice. If the problem set were merely the selection of one effective movement out of several haphazard movements, as was the case with the puzzle-box experiments reported by Dr. Thorndike[1] and my-

[1] *Loc. cit.*

self,[1] then the profiting by experience could be accounted for by the fading away of the useless movements. They would drop off like dead branches from a tree, of their own weight. They would be associated with nothing—either positively or negatively. The right movement would be selected *naturally*. In the present case, however, two direct associations are formed and discriminated between, and the advantageous one selected. Recognition of the critical places is equivalent to doubt as to the right path. This doubt is the correlative in consciousness of the struggle between the two associations or 'constructs.'[2] The positively useless or the less advantageous association does not fall away mechanically, but only in virtue of discrimination between the two constructs, and, finally, the conscious selection of the right one. In such a case as that of choice at x if the animal did not consciously select, there could never be any fixed association; consequently never any habitual reaction. Both ways lead to success. In a sufficient number of trials the theory of probabilities would require an equal number of selections of each path. But the short road is soon habitually selected, just as is the right path at other critical points. There is involved an elementary form of comparison and judgment; for comparison, judgment and reflection, even, are present in embryo. They all take their rise in the struggle of ideas and images, and lower down of 'constructs,' which "gives in animal, as in man, the illusion of choice and free intelligence."

Modalities of Sensation.

This section is an attempt to appreciate the rôle of the different sense-modalities in learning the task.

The conditions of the experiment were such as to exclude any very direct influence of taste and hearing. Taste gives only a pleasurably-toned experience at the end, the significance of which has been noted. The influence of hearing is limited to occasioning affective variations. Neither gives any data for solving particular difficulties.

Smell. The sense of smell might be supposed, *à priori*, to play the leading rôle, but in the present case its claims to primacy are doubtful.

In the preceding section it has been shown that the location of the food by odor, and hence the end to be reached, was an unimportant factor. In fact, it is improbable that olfactory sensation *per se* has much greater spatial significance with animals than with man. In general, animals perceive direction of odors only with the aid of air currents. The perception is quite as much tactual as olfactory.

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[1] *Loc. cit.*

[2] *Cf.* Morgan: Comparative Psychology.

It is even clearer that the trail of the first accidental success was not followed subsequently by scent. In the first trial the rats invariably traversed practically all the galleries; and, after appeasing their hunger a little, carefully investigated the entire maze. It would be impossible, therefore, for them to select the right path by scenting the trail. Again, the second rat frequently turned aside from the route marked out by his immediate predecessor; either he was not following the trail or he could not discriminate the fresh trail from one a day old. Further, the recognition of critical points, and the fact that the rats frequently ran long distances with heads up—*e. g.*, when carrying food—are evidence against the supposition. These facts together are sufficient to throw the theory out of court.

The conclusion is drawn for the present case only. It is perfectly apparent that animals of this class do follow trails by scent in the right circumstances. These facts point to the complexity and variety of the animal mind, and are a warning against naïvely accepting 'simplest explanations.'

Another possibility in regard to smell is that particular points in the maze may have been associated with definite peculiarities of odor. The constant sniffing and extensive olfactory investigations of the rats lend color to this thought. The experience thus acquired, may, however, influence only the affective tone—connect directly with the emotional tendencies which determine the animal's conduct. Such a relation is indubitable. I found, for example, that putting rats perfectly familiar with the task, into a new maze, differing from the one learned only in *newness*, threw them into extreme emotional excitement. They acted as though the task were absolutely new to them. They were curious, timid, and hesitant; errors were as frequent as in their introductory trial. After finding the food, they continued eagerly exploring and re-exploring the maze. As soon, however, as they had become familiar with the new odors, their former facility returned; they made the journey as quickly and accurately as before. This would not have occurred, had it been necessary for them to establish a new series of smell-position-direction associations. The inference is clear that the effect of smell sensations is general and emotional, rather than that delicate and discrete associations of odors with special positions are set up. The point, however, is not absolutely secure. Probably more conclusive evidence might be obtained by testing rats with olfactory nerves paralyzed.

Sight. Sight is much less relied upon, and, relatively, much less acute than smell and hearing—the psychic organs respectively of food-getting and defence. This corresponds with the poor development of the eye and optic nerve.[1]

[1] The eye of the wild brown rat is better developed than that of the white rat, but the two rats varied slightly in their conduct in the maze.

Several tests were made, the results of which indicated that visual perception played no part in the processes of recognition and discrimination.

1. It was suggested to me that the direction of light, by analogy with Lubbock's[1] experience with ants, might be a factor in the chance of path. Lubbock found that "when the direction of the light was changed, but everything else left as before, out of seven ants, five were deceived and went in the wrong direction." (This was after they had learned their path perfectly, of course.) Fortified by further experimentation, Lubbock concludes that "in determining their course the ants are greatly influenced by the direction of the light."

As the rats did most of their exploring in the dark, and as the brightness element is only one factor in the visual datum, not the total datum as with the insect, it was improbable that this factor should be very influential. Nevertheless, it was made a matter of experiment. Tests were made by having the rats learn the path perfectly with the direction of the light constant. The light was then transferred to the opposite side for a few trials; after which, it was alternated at unequal, though frequent, intervals. The results were: (1) In most cases, change of direction of the light seemed to produce a very slight effect upon certainty and celerity of movement; but hardly more than might occur as normal variations under constant conditions. (2) Some subjects showed absolutely no effect. (3) After the first change the alternation produced no effect. This shows that the effect when it occurred was merely a slight affective disturbance—a retardation, not a change of the cognitive process. Plainly this is a very minor factor.

2. A partial test of the part played by sight in the recognition and discrimination necessary to the formation of special associations at critical points was made as follows: At all such points, bright red posts, ¼ inch diameter, were placed in the middle of the right path a few inches beyond the dividing of the ways. When the rats had learned the path perfectly the posts were removed. Two rats only were tried, the results being *nil*. These rats did not learn the path more quickly; nor did they exhibit the slightest variation in conduct after the posts were removed. It is tolerably clear that visual data, if effective, must e of a more general character. The animal does not hang his ssociation upon a gross and obvious object.[2]

3. Another method of partial experiment suggesting itself was blindfold the rat after he had learned the path. The evident

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ıbbock: Ants, Bees, and Wasps, p. 267 ff. (6th Ed.).
is improbable that the action had become so habitual as to dis-e with what was at first a determining factor in the formation of ·ssociation.

objection to this plan is that it would change completely the conditions of attention and emotion. If the subject blundered and failed nothing would be proved. If he did his work about as well as before there would be a negative demonstration of the slight importance of visual perceptions; *not, however, of visual sensation*, for its effect might still be present as visual images co-operating in the mental process.

Fortunately, nature stepped in and performed a conclusive experiment for me. A number of my rats came to me with diseased eyes. Before I discovered this, two of them, an adult male, *X*, and a young female (about 10 weeks old), Y, had become blind. I had already started them learning the maze, with two others, when I noticed their blindness. After the fifth experiment they were totally blind. In the first two experiments distinct impressions—if white rats have such—may have been possible to *X;* and brightness sensation until the fifth. Rat *Y* may have had brightness sensations in the first two experiments, but not later. At this time the general health, vigor and temperament of these rats were unaffected by their malady.

The results of the experiments with these blind rats were so striking that I give them somewhat fully. Until after the ninth trial, the two normal rats were continued with the blind ones. They were then removed, and thirteen more experiments were made with the blind ones. Following that, the latter were tried in the reversed maze. The blind rats learned the original task as well as the normals—all the normals experimented with. Rat *X* in this case learned the path before either of his normal companions. In Exps. 5 and 6 he was first to C, and made fewest errors. In Exp. 7 he made the round in 50 seconds, without error, and with slight hesitation at two points only. In the succeeding 15 experiments he showed practically perfect acquaintance, though occasionally making errors. His conduct in the maze did not differ materially from that of normal rats. He ran in the middle of the galleries, rounded the corners quickly and precisely, and carried on the usual investigations. At critical points there were the same hesitation and indecision manifested as with the normals, by alternately turning each way as if stayed in the grasp of conflicting images. Occasionally he would nose along the several sides before starting on again. This probably was not a direct means of ascertaining the way, for, later, I cut off his feelers, also those ot some normals, without any effect upon their ability to find their way.

The results with Rat *Y* were even more interesting, as she was certainly totally blind after Exp. 2. She was somewhat longer in learning the way than *X* and the normals. At

first she was slow and diffident in starting, and less facile in getting about; she ran somewhat gropingly, and frequently almost bumped into the ends of the galleries. These defects soon wore off, and she kept her path and rounded the corners as nicely as the others. Certain errors, however, clung persistently, notably at *2* and *3*. After Exp. 3, she had little difficulty beyond *3*. Until Exp. 11, she went each time to the end of *2* and *3* as mechanically as if these were essential stages of the journey. I began to wonder whether the habit was so firmly fixed as to defy the benefit of chance experience. In Exp. 12, however, *2* was dropped out; in Exp. 13, *3* was dropped, but *2* reinstated. In Exp. 15, *2* and *3* were finally eliminated, and did not reappear. In the last 7 experiments she made no errors and seldom hesitated or showed indecision. This blind rat thus eliminated errors that had become almost automatically habitual. The experiments with the reversed maze[1] gave the only suggestion of importance of the visual factor. The blind rats when first put into the reversed maze were more disoriented and confused than the normals. Not until Exp. 3 did *X* succeed in getting to C.[2] The normals, on the contrary, seemed to have profited by their experience with the other maze. They made better time, fewer errors, and showed less indecision than in the first experiment in Maze I. They fell off badly, however, in the second trial. The discrepancy between the blind and the normals quickly disappeared; in Exp. 5 the blind rat did as well as the normals. So also, in the successive alternations of the mazes, the blind rat perfected his distinct knowledges of the two as quickly as the normals.

This slight superiority of the normal rats, however, does not seem to me to mean that visual data exerted a determining influence. Rather, with the blind rats the motor element was so exclusive in the reproductive process as to make readaptation proportionately more difficult. With the normals sight, though probably contributing no determining data, served to distract attention from the established reproduction. Sight certainly is not a *sine qua non* in the process of experimental reasoning incident to these experiments. Its service is superficial, and may be dispensed with almost without loss. Its office in the essential processes of recognition and discrimination is hardly

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[1] The method of experimentation was to transfer the subject, after he had mastered the original maze, to the reversed form—*i. e.*, right and left interchanged. After this reversed form was learned the rat was returned to Maze I. The mazes then were alternated till both were learned perfectly.

[2] Rat *Y* died in Exp. 3, so these data are from observations of Rat *X*.

appreciable. Its forces are deployed in the background of consciousness; they do not get into the forefront of action.

By this process of elimination the conclusion emerges that the tactual motor sensations furnish the essential data for the recognition and discrimination involved in forming the special associations at critical points. How the animal recognizes critical points it is impossible to say. The most reasonable supposition is that in the gradual formation of the motor memory of the entire course, at the established distance-intervals, the conflicting images of turning in one direction or the other spontaneously arise, resulting in indecision—the sign of recognition. There is some positive evidence in support of a distance quality in the animal's image to be remarked below. The machinery of discrimination seems tolerably clear. In any given case it consists of direct association of *the motor image of turning in one direction* with success, and the motor image of turning in the other direction, with failure. This is the explanation in the cases where one alternative is a blind alley. In the cases where the alternatives are longer and shorter we have to suppose an association between direction and distance; between turning in one direction and the distance traversed or *the time consumed.* Perhaps the quality is temporal rather than spatial; or indeed it may be that the temporal and the spatial *qualia* of this modality of sense are undifferentiated in the lower animals. The positive evidence of the distance quality noted above appears in the fact that the rats quickly adopt the shorter road where there is choice of longer or shorter. It has been pointed out that all the rats experimented with learned, sooner or later, to take the shorter road at x. Inasmuch as both roads lead to Rome it is difficult to see why the shorter one invariably should be selected, unless it is known as shorter, or, in other words, unless quicker satisfaction is associated with this path than with the other. It is equally difficult to see in what terms this association could be mediated other than those suggested—a distance or temporal idea in tactual-motor terms.

The fact of the invariable adoption of the 'shorter circuit' was brought out more clearly and forcibly by a special test. A normal and the blind rat X were used. Both had been familiar with both mazes (direct and reversed) for weeks. Their knowledge was as nearly automatic as possible. A path was opened, then, between d and h, by cutting the walls at w and z. A large part of the first (left) half of the journey thus was cut out.

In the first trial (normal rat) the rat went automatically *via* the old route—paid no attention to the new one. He likewise went directly by the opening at z when he came up from e. In the next trial, however, he took the new path unhesitatingly

through *w* and *z*, and turned correctly—*i. e.*, to the right—at *h*. In the third trial he took the new path, turned correctly at *h*, then paused and went half way to *e*; paused here again, made several abortive movements each way, but finally turned correctly and went forward to C with confidence and speed. In the next two trials the right association became pretty well fixed; the new route was learned perfectly and the old abandoned.

The conduct of the blind rat was really striking. In the first trial he did not notice the new path. In the second, however, he selected it after brief hesitation. The experience of the preceding night was thus strikingly effective. Singularly enough, he perfectly acquired the new association more quickly than the normals.[1] After the second trial he rarely went astray. In all three cases, however, the old habit was quickly broken, and a new, more advantageous one established. This preference for the shorter path is difficult to explain except upon the supposition that the path is known as shorter. To charge it up to the animal's "short-circuiting tendency," or his "tendency to eliminate useless movements" is to beg the question. Unless the advantage of the new path over the old is known in some way the old habit would persist simply in virtue of its own inertia. Again we cannot speak of a direct connection between *turning* in one direction and satisfaction; no such association is formed directly. A direct association is admitted; but it is formed only after experience with both paths, and deliberation often repeated between them. It is difficult to see what the association turns upon, if not upon distance-direction ideas of motor origin.

Why should not the repetition of the same motor expenditure establish in the psychophysical organism a path, the conscious concomitant of which is capable of being discriminated from similar feelings of other expenditures, and capable of reproduction under appropriate conditions?

The chief obstacle in the way of realizing to ourselves the existence and character of such representations as those suggested above is our lack of experience with pure tactual-motor ideas. It is a pertinent illustration of the influence of psychophysical limitation. We recognize that tactual-motor experience is fundamental in our own spatial perception; but it is so grown over and obscured by visual experience that it is next to impossible for us to realize in ourselves a pure tactual-motor image. No fusion of elements is more complete than this. The imperfect isolation we are able to give the tactual-motor element in

[1] A second normal was tried with results essentially the same as obtained with the other.

our own representations helps us, however, to imagine the pure idea of this kind. I observe that my own representation of the course through the maze is strongly motor. I find it just as impossible to see the course as a static visual image as to abstract the motor image from the interfused visual elements. I can alternately make one or the other focal, though the motor seems less *real* than the visual. This imperfect and mongrel tactual-motor experience of ours gives, however, a remote suggestion of the quality and feeling of such ideas in their pure condition. When we consider the clearness and definiteness of the spatial ideas of the blind deaf-mutes it ought not to be very difficult to conceive that an animal of poor visual endowment, or of semi-subterranean habits of life, may do a large part of his thinking in tactual-motor terms; and that the content may have a clearness and fullness of meaning hard for our visually over-slaughed minds to appreciate. With no feature of this study have I been so impressed as with the possibilities it reveals of thinking in motor or tactual-motor terms.

In carrying on this study I have profited greatly by aid and suggestions from many persons, and also from many books. I wish especially to express my indebtedness to Dr. E. C. Sanford for the initial suggestion, for ample laboratory facilities, and for continued interest and helpful criticism; to Dr. L. W. Kline for practical suggestions; to President Hall, and the members of his seminary, for salutary and stimulating criticism. The published works which I have found most helpful are those of Professors Lloyd Morgan, Wesley Mills, and Edward Thorndike, and the *Examen psychologique des animaux* of M. Pierre Hachet-Souplet.

A COMPARISON OF JUDGMENTS FOR WEIGHTS LIFTED WITH THE HAND AND FOOT.

A. J. KINNAMAN, Fellow in Clark University.[1]

INTRODUCTORY.

This series of experiments, begun in October, 1899, was undertaken for the purpose of determining the relative sensibility for "lifted-weights" through large and small muscles. At first attempts were made to use the large muscles of the leg and a flexor muscle of one of the fingers. That selection of muscles was soon abandoned because of the extreme difficulty, if not impossibility, of experimenting with the two muscles under anything like similar conditions. Finally it was decided to use the hand and foot as involving in a general way, large and small muscles. This then turns away, in part, from the original problem, but still involves the original to the extent that the muscles of the leg are larger than than those of the arm. Though suggestive, the experiments are in no wise conclusive as to the large and small muscle problem.[2]

After various attempts to eliminate the weight of the arm and leg, partly or wholly, this idea also was abandoned. It was taken up, however, in a second series of 4,500 tests not reported in this paper. The following is a report on 9,000 of the total 18,000 tests made. It is hoped that there is here furnished a reasonably safe answer to the question implied in the title of the paper, at least for one reagent.

The "standard weights" selected for this series of experiments are nine: 100, 400, 800, 1,200, 1,600, 2,000, 2,400, 2,800, and 3,200 grams respectively. Upon testing, the last weight proved to be about one-fourth of the reagent's maximum lift with the outstretched arm. The maximum lift for the leg proved to be about equal to that of the arm.

It was at first the intention to include larger standards up to

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[1] This paper was prepared as a thesis for the A. M. degree at Indiana University. The experiments were made under the direction of Dr. W. L. Bryan. Valuable suggestions have been given, also, by Dr. J. A. Bergström, Dr. Sanford and Dr. Hall.

[2] Bernhardt experimented incidentally with large and small muscles in a study of "Muscular Sense." Archiv. f. Psychiatrie, III, cited by Ferrier's Functions of the Brain, p. 391.

6,400 grams, that is, to one-half of the maximum lift.[1] But the larger weights could not be experimented with extensively, without excessive fatigue or even physical injury. The likeness of this scheme to Fechner's makes comparisons of results practical and suggestive.

Jaccoud,[2] Leyden,[3] Bernhardt,[4] Sunkel,[5] and Hitzig[6] have made experiments on weights lifted by the foot. In Jaccoud's tests twenty-four ataxic patients lifted weights ranging from 100 to 3,000 grams to determine whether such patients could recognize weight, and to some extent the differences of weight which might be recognized by them.

Leyden, Bernhardt and Hitzig experimented with normal reagents by the method of "Just-observable Differences."

As yet no very extensive experiments have been made with foot-lifting, and none to compare accuracy of judgment through hand and foot in the same normal reagents, so far as I know.

APPARATUS.

The apparatus usually employed in lifted-weight experiments could not be used here. Fechner and Müller used essentially a rectangular base, from the corners of which brass rods extended upwards. These met in pairs at the ends, and were connected across by a wooden handle like that of a bucket bail. The weights were placed in the bottom of this rigid frame. While admirably suited for hand-lifts, this apparatus could not be used for the foot, but the lower portion of it could have been employed, doubtless, to some advantage. This is true especially of the method of arranging the weights and their respective instruments, *Zusatzgewichte*. In Fechner's apparatus this increment was placed in a small box which in turn was set into an opening in the center of the base. Thus every portion of his apparatus was firm and rigid.

Leyden in his foot-tests had a kind of pocket fastened to a band which hung over the instep. The weights were put into this pocket. Hitzig had the heel of a stocking sag downwards pocket-shaped and put the weights in this.[7] Bernhardt's reagent lay on his back and had a band around the instep of the foot. From the band a string passed under one pulley then upward over two others, and was attached to a small board on which the weights were placed.[8]

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[1] Wreschner used 15 weights. The largest weighing 8,000 gr. Methodologische Beiträge. Leipzig, 1898.
[2] Paraplegies et l'ataxie du mouvement. Paris, 1864. p. 665.
[3] Ueber Muskelsinn und Ataxie. Virchow's Arch., 47, 321.
[4] Zur Lehre vom Muskelsinn. Arch. f. Psychia., III, 618.
[5] Inaugural Dissertation. Marburg, 1890.
[6] Neurol. Centralbl., VII, 249.
[7] Neurologisches Centralblatt. 7, 1888, 249.
[8] Arch. f. Psychiatrie, III, 628.

In attempts to devise apparatus equally suitable for both hand and foot, several forms were tried and rejected, which need not here be described. That used in these tests consisted of: (1) A board 6 x 8⅛ inches, the upper part of which was covered with a thick piece of cloth to avoid sounds and jars that might result from moving the increment; (2) Four strings attached to the four corners of the board, and meeting at a common point nine inches above the center of the board, where they were tied together and fastened to a single cord which continued upward about an inch. This single cord was inserted between the ends of the four strings and the collar above on the hand (or foot) so that if weight or increment should be placed, or slip, to one side, the variation would affect the direction of the suspended weight and the normal sensation as little as possible. To provide further against such effects the board rested on a thin cushion, so that the beginning and end of the lift might be affected as little as possible by any tipping of the board that might occur from a failure to center the weights properly; (3) A cylindrical band of heavy cloth with the diameter great enough to receive the fingers and palm of the hand (or the toes and a part of the foot). This band was sufficiently close-fitting to allow one to draw it to a given point and thus to keep it always in the same position and at a uniform distance from the joint. And since the arm is a lever this arrangement kept the distance from the weight to the fulcrum and power uniform. Over this band was fastened another of the same width but of greater length. It was sewed to the cylindrical band in a line along the upper side. The under side sagged downward about two inches, where it was gathered and tied to the single cord from below. This apparatus could be shifted easily from hand to foot, and was applied to about equal sense areas.

The apparatus, including the band, weighed 100 grams. The band alone weighed 26 grams. This series of experiments is at fault in that the weight of the band was on the hand constantly during each series of hand-tests. This was true, also, with the foot. Whatever absolute error in sensibility resulted from this source, its effect would be slight in comparing judgment for hand and foot, since both were subject to the same disturbing condition.

This error in apparatus should affect the absolute sensibility for the smaller weights more than for the larger ones, the band being proportionally a much larger part of the standard weight for small than for large weights. For 100 grams the weight of the band was one-fourth of the total standard; for 400, one-sixteenth; and for 3,200, only one one-hundred and twenty-

eighth. Leyden, Bernhardt and Hitzig appear not only to have left the apparatus on the foot while experimenting, but to have disregarded its weight, for they speak of distinguishing between 0 and 50, 83, 90 and 100 grams. In our tests the weight of the apparatus was always considered as a part of the weight to be lifted.

Standard gram-weights and books were used for standard weights. The increments were in the form of small muslin bags loaded with fine shot. In order to get results best suited for calculations by the tables in Dr. Sanford's Manual (p. 356), larger proportional increments were used for the smaller than for the larger weights, and for the foot than for the hand. These per cents were:

		100	400	800	1200	1600	2000	2400	2800	3200
Standards,										
Increments	Hand,	10	7	5	5	4	4	4	4	4
	Foot,	20	15	8	7	5	4	4	4	4

The particular selections of the above per cents were based on recorded experiments and on some 5,000 preliminary experiments not reported here. The larger per cents were used with the smaller weights in an attempt to get something near eighty-five per cent. of correct judgments, as giving best results with the current tables. In some respects it would have been better to use the same per cent. of increment throughout, as Fechner did. Such a plan gives greater significance to the doubtful cases. The varying per cents of increments allow no common basis for calculation of such cases.

Methods of Experimenting.

The experiments were made in sets of twenty of a kind divided about equally between heavy-first and light-first presentations, and were distributed as usual to avoid inequalities due to fatigue, training, the establishment of standard sensations, etc. Thus, a set of 20 tests with the hand, standard 100 grams, was followed by 20 tests with the foot, standard 100 grams; this, with hand, 400 and foot 400; and so on up the scale and back again. This was followed by foot, 100, hand, 100, etc., up and down the scale as before.

The individual tests were twenty seconds apart, and the two lifts constituting a test about two seconds apart. The latter time was not specifically measured, but was determined by the time required by the operator to place the increment on or take it off the apparatus, and to signal by tapping the hand or foot of the reagent. This time was very nearly uniform, and effort was made to keep it so. Variations from this source would be

almost equal for the foot and the hand. The average variation would render comparisons practically exact.[1]

Great pains were taken to keep the speed of the lifts uniform, and the same for both hand and foot. The speed has been shown to be a very important factor in the judgment of weights.[2]

An attendant noted the time for each test, moved the increment, signalled for the reagent by a gentle tapping of the hand or foot, determined whether a light or heavy presentation should be made, and recorded the results. The reagent had eyes closed and ears bandaged.

When tests of the hand were to be made the reagent sat on a dining-room chair by a table, with the arm outstretched and the hand projecting beyond the edge of the table. The board of the apparatus rested on the top of a piano stool, the supporting strings slightly loose. On receiving the signal the arm was kept straight and lifted. The stool was just high enough for the weight to clear it when the hand was about three inches below the level of the shoulder. The weight was then lifted about three inches and again lowered to the stool.

It is customary to gauge the height of a lift by a cord. The form of the apparatus made it quite impossible to do this. The writer is of the opinion that slight variations in height of lift are of but little consequence, since he appeared to base his judgments on changes of sensations at the beginning of the lift. After the lift the arm was again replaced on the table. As soon as the increment was changed and the signal given the lift was repeated. The result of judgment was announced by the reagent immediately after the second lift in each test. In the foot-tests similar precautions were observed, and the same plan of experimenting was followed.

In these experiments it will be noted that but two weights were used in testing a standard, 100, and the comparison weight, 110, when the smaller was presented first; or a standard, 110, comparison weight, 100, when the larger one was pre-st. In the former case the increment was 10 per cent. ndard; in the latter it was 9.09 per cent. This fact taken into account in working up the results and de-he curve.

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mes Swift (*Amer. Jour. of Psychol.*, V, 1-19) has shown time is materially lengthened by distracting the atten- ticking of a metronome. Accordingly one would expect ble distraction from a metronome to induce a higher per rs in weight-judgments. But Dr. Margaret K. Smith has thmus und Arbeit" that all but one of her reagents ren- judgments when weights were lifted with the tick of the han without it.

d Schumann: Pflüger's Arch., XLV, 37-112.

Some experimenters[1] use a standard weight and then comparison weights of a given per cent. larger and smaller than the standard. Thus with 100 standard would be used 110 and 90; one, ten per cent. greater, the other, ten per cent. less than the standard. If it is desired to get a judgment on the basis of a ten per cent. increment it appears that the method employed in our experiments is more nearly correct than the foregoing method. Taking 90 and 110 for comparison weights, the greater is more than 20 per cent. greater than the lesser, and the lesser slightly less than 20 per cent. smaller than the greater. In case of such a method being used, judgment is rendered more on difference between comparison-weights than between standard and comparison-weights. One could render judgment heavier than standard or lighter than standard, after experimenting for a while, quite as well without the intervention of a standard as with it, on account of the great difference in the comparison weights. I find that this view has been expressed lately by Martin and Müller in their experiments on lifted-weights. They say: "We are by no means of the opinion that a comparison of weights never takes place. Those comparisons, however, which are the easiest to determine, are, strange to say, not comparisons between standard and its variables, but a comparison between a variable which has just been hefted and the variable of the immediately preceding experiment."[2]

In these experiments the reagent knew: (1) That there would be twenty tests in the set, divided as stated above; (2) That not more than four of a kind would come together; (3) Sometimes he knew that he had missed a given number in a previous set of the kind about to be undertaken; (4) That about such and such results might be expected from the hand-tests, *e. g.*, the light-first tests would show a higher degree of sensibility than the heavy-first tests would.

This makes the series, so far as absolute results are concerned, subject to some of the adverse criticisms directed against Fechner's work,[3] in addition to those already mentioned. Fechner, it will be remembered, was both operator and reagent in his experiments. Introspective observations, however, seem to indicate that the knowledge named above acted more as a spur to attention than to any other end.[4]

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[1] Wreschner: Metholodische Beiträge, Leipzig, 1898. Martin and Müller: Zur Analyse der Unterschiedsempfindlichkeit, Leipzig, 1899.

[2] *Amer. Jour. of Psychol.*, XI, 269.

[3] Fullerton and Cattell: "On the Perception of Small Differences," p. 116.

[4] For experiments with similar limitations, and a discussion of the same, see Psy. Rev. Sup. I, 31.

Practically two forms of answers were given; "second lighter, or heavier," when the distinction was clear; "second lighter, or heavier, D [doubtful]" when there was a very low degree of assurance. Introspective observations of various kinds were often noted in addition to the foregoing answers.

The results were worked up according to the method of Right and Wrong Cases, following Fullerton and Cattell's suggestions, and using the tables and methods of calculations offered by Dr. Sanford in his Manual.

In these tests an answer was always required from the reagent, however great his feeling of doubt. Investigators have not always dealt with the doubtful cases in this way. Fechner divided the doubtful cases equally between right and wrong judgments.[1] Wreschner threw them away;[2] Kraepelin, Jastrow, Fullerton and Cattell, and Higier required that the reagents should always answer no matter how great the feeling of doubt.

Table and Curve.

This curve and the accompanying table show the sensibility of the reagent's hand and foot and of Fechner's hand according to the method of Right and Wrong Cases. In determining sensibility from Fechner's experiments his right-hand tests were used. That the two series of experiments might be put on a par as far as possible, the three, five and ten hundred-gram tests of his were selected from sets where an increment of eight per cent. was used, while the others were taken from his tests with a four per cent. increment. Thus in this and in his series we have a large per cent. of increment with the lighter standards and a small per cent. with the heavier standards.

A comparison of Fechner's sensibility-curve with that of the reagent's hand in these tests will show them to be very similar in general form, though slightly different in detail and elevation. Individual differences, differences in apparatus, differences in methods of experimenting, and in the number of tandards taken will, doubtless, account for the slight differces in results, was determined from the data on page 186, Vol. Psychophysik, 1889, with a full realization that he and the ter dealt quite differently with their doubtful cases. The parison, therefore, is not fully justifiable, but is offered for tever it is worth.

Fechner's experiments six standards were used, while were used in these. This would tend to make his curve ear the more regular of the two.

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1. d. Psychophysik, VIII, 72.

2. *mer. Jour. of Psychol.*, IX, 592. Gesellschaft fur psychologische hung. Heft II (III Sammlung).

Curves of Sensibility or Power of Discrimination. (9,000 tests.)

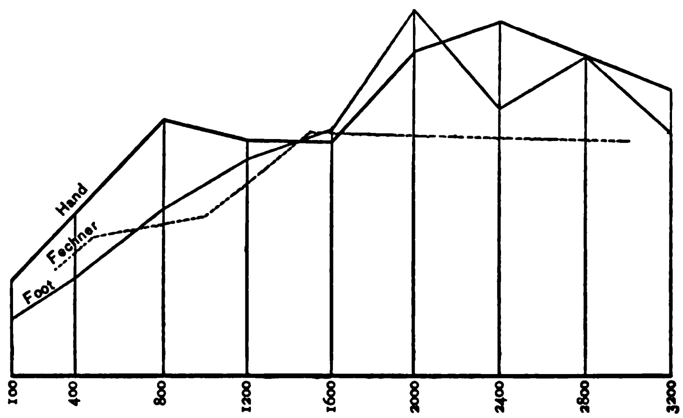

Table of Sensibility.

Standard W'ghts.	Hand.	Foot.	Standard Weights.	Fechner.
100	.093	.053		
400	.156	.094	300	.103
800	.242	.160	500	.132
1200	.228	.207	1000	.151
1600	.226	.231	1500	.232
2000	.328	.347	2000	.232
2400	.336	.251		
2800	.308	.308		
3200	.276	.235	3000	.229

Individual differences are often very great, however, and they alone could account for the variations in the curves.[1] For example, by the method of just observable differences Leyden's reagents showed a fineness of judgment for the foot double that of Bernhardt's. Müller and Schumann's subjects were less than half as sensitive as Fechner for certain weights.[2]

The grasp or hand-hold is probably an important factor. Cattell and Fullerton (Perception of small differences, page 118),

[1] Griffing: Psy. Rev. Sup., I, 42.
[2] Schäfer's Text-Book of Physiology, II, 1021.

with small wooden boxes to be grasped by the sensitive fingers, obtained an average sensibility of 161 when a standard weight of 109 grams was used. In these experiments, however, with a less active grasp and an appeal to a less sensitive dermal area[1] the sensibility was but .093, or about 9-16 as fine as theirs. Active effort undoubtedly enables one to judge more accurately than passive effort. Merkel found judgment based on active movement of the beam of a balance to be to passive pressure as 17 to 13.[2]

For the lighter standards this apparatus appealed to very small areas; but for the heavier standards, to large areas. The lightest weights merely produced slight movements in the band when the weight was lifted. The sensations from lifting the two weights appeared to differ only in that the band with the heavier weight rubbed the skin a little more than the lighter, usually along the side of the index finger. Fechner's apparatus, for the lighter standards, appealed to a larger area. Whether this difference of area affects the sensibility is a matter of dispute. Lemon[3] says it does, while Griffing[4] says it does not. In any event the curves show that where the dermal areas appeared to vary most, there the sensibilities vary most; yet the variation of sensibility may be due to other causes than differences of area.

There is probably a significant difference in the rigidity or firmness of the apparatus used. That used by Fechner, Müller and others consists essentially of a firm metallic or wooden frame, while that used here consisted largely of fabrics. With the solid frame the weight clears its base of support more suddenly than with our apparatus. With a rigid piece of apparatus a given speed of lift will make the changing sensations at the beginning of the lift pass more quickly than where the apparatus is less rigid. With our apparatus there is but little tendency for the weight to *fly up*. It is probable, also, that slight variations in the speed of the lift will affect judgment less with ... apparatus. Upon the whole the other apparatus appears ... exact, and should be used wherever possible.

... and these curves follow each other much more ... any others[5] that the writer has seen.

... hand and foot curves in this chart, they closely ... other, even in detail, except at 2,400 grams. ... is probably accidental.

[1] ...he sensibility of the tip of the finger is to that of the ...d as to 1 and 5. Weber; cited by Bain: Senses and ...sidered as an Organ of Sense, p. 46.

[2] Phil. Stud., V, 287.

... p. 128; also Supplement I Psy. Rev., p. 47.

... r and Schumann.

The curves show at first a rapid increase of sensibility to about the 800-gram standard, followed by a less marked increase up to 1,600. Then they rise rapidly to a maximum sensibility at 2,000 and 2,400, after which a slower decrease sets in. The cause of this change at from 800 to 1,200 grams is discussed under Hypothetical Considerations, further on in the paper.

The few tests made with much larger weights seem to indicate the continuation of this downward tendency in the curve, showing a further decrease in the sensibility. These tests with very heavy weights were not numerous enough to demonstrate anything, but at 6,400 grams, one-half of the reagent's maximum lift, they indicated a sensibility of not more than .125, which is less than that obtained with a standard of 800 grams. In the latter part of the paper, under "Hypothetical Considerations," is offered an explanation for this increase of sensibility, observed by all experimenters, as the scale of weights is ascended. In that section of the paper an attempt will be made to show that it is due to the influx of additional bases of judgment. The decrease of sensibility in the very large weights will be accounted for on the basis of an influx of distracting influences.

The difference in sensibility of the hand and foot, beyond 1,200 grams, is very small. The larger difference with the lighter standards may be due to finer dermal discrimination in the hand than in the foot, the basis of judgment for these standards being largely dermal.

Dr. Krohn has shown[1] that exposed surfaces locate better than portions usually covered with clothing, and Weber[2] found the sensibility for points on the dorsum of the foot to be to that of the palm of the hand as 5 to 18. Todd and Bowman[3] hold that the relative power of different parts to estimate weights corresponds very nearly with their relative capacities of touch, and Bloch[4] shows the weights, for just observable pressure for the palm of the hand and dorsum of the foot, to be as 1 to a weight ranging from 40 to 60.

These views put together make it appear altogether probable that there is a decided difference in the pressure and touch sensibility, for the dorsum of the foot and for the palm of the hand, and that this may account for the difference of sensibility as shown in the first part of the curves. But this difference is so small that it may be said, in general, that within the first quarter of the reagent's range of lifts, the sensibility of the foot for

[1] Psychol. Rev., 1894, p. 326.
[2] De pulsa, resorptione, auditu et tactu.
[3] Brit. Med. Jour., XIII, 430.
[4] Arch. de physiol., III.

lifted-weights is about equal to that of the hand, even though the foot had never before been used in lifting weights.

TABLE II.

Percentage of errors in the successive tests in all of the sets of twenty for both hand and foot.

No. of Test.	% of Wrong Judgments.	No. of Test.	% of Wrong Judgments.
1	30.23	11	22.66
2	18.22	12	24.88
3	21.33	13	22.66
4	19.77	14	18.88
5	23.77	15	23.99
6	24.00	16	19.77
7	23.50	17	23.12
8	21.11	18	23.55
9	20.88	19	26.21
10	26.21	20	24.33

This Table shows that on the average the first judgment in each series was poor, there being an average of 30.23 per cent. of errors for both hand and foot. While the average of the second tests shows only 18.22, or the smallest average per cent. of error in the whole set of twenty tests. This sudden improvement, after the first test, is the most characteristic thing shown in the Table. It is probably due to accommodation and setting up a standard sensation. It could hardly be due to increase of effort at attention over that rendered to the first test. It seemed to have taken the time up to the second test for the reagent to adjust himself to the series. Usually the attention was most intense at the beginning of the series, then a restful feeling of assurance, after three or four tests, was very common. If it be true that we underestimate weights when attention is intense,[1] that should not affect our judgments in comparing weights, as both standard and comparison-weight would appear equally reduced.

When concentration failed, as it did of necessity, occasionally, it never occurred with first, second, third, fourth or fifth tests. Introspectively, at least, the reagent would be of the opinion that attention was always most intense with the first test. Whenever attention was grossly at fault the reagent, without knowing the correctness or incorrectness of his answers, requested to be taken again over the last four or five tests, he not knowing exactly how much territory he was retracing. But every effort was made to keep attention uniform.

These tests it will be remembered were made twenty seconds apart. From last lift of one test to first of the next was about sixteen seconds. The standard sensation bridged over this time so distinctly that the reagent was able to render, in mind, after

[1] Psychol. Rev., I, 44.

the first lift of each, nearly one-half of the time, the same decision that he did render after making both lifts. The standard or absolute sensation, therefore, appears to have been an important factor in forming the judgments. In this view the charts and introspections here quite agree with Angell and Harwood, and with Martin and Müller, as stated by Angell in his review of the Martin and Müller article.[1]

Following the sudden improvement after the first test there is a slight general increase of error toward the close of the series, probably due to fatigue and diversions of attention. The principal factors entering into these variations are attention, fatigue and the establishment of standard sensations.

It is evident that the disturbances on the whole are not very great. For example, the first ten tests show 22.90 per cent. of errors, and the last ten 22.91 per cent.

But it is impossible in this study to isolate and measure these factors. Fatigue and inattention would tend to increase the wrong judgments, while the establishment of a standard sensation would tend to a decrease of the same.

The effect of training or practice was calculated and found to be very slight, the judgments through the foot showing a little more improvement than those through the hand. This extremely slight improvement, as shown in these experiments, is not so remarkable when we remember that about 5,000 tests had been made before this series was taken up.[2]

SUMMARY OF RESULTS.

I. In answer to the main question of Comparison of Judgments: (a) The weights were discriminated a little better through the hand than through the foot; (b) The relative difference was greater for the small than for the large standards; (c) Both showed a lower degree of sensibility both above and below 2,000-2,400 grams, or one-third of the reagent's maximum lift; (d) The practice effects were small and about the same for both hand and foot; (e) The discrimination of the heavy-first presentations differed from the light-first presentations in the foot-tests less than in the hand-tests. (This fact has not been discussed in this paper. For the hand the variation was slightly above the average. For the foot it was probably less than the average hand-variations.) (f) The sensation seems to be partly a touch and partly a muscular sensation as observed by Fullerton and Cattell; (g) The fineness of discrimination is not materially disturbed by the fatigue resulting from

[1] *Amer. Jour. of Psychol.*, 1899-1900, p. 260.

[2] On effect of training see Wreschner, Metholodische Beitrage, p. 183. Leipzig, 1898, pp. 238.

a short series of tests; (h) Standard sensations play an important rôle in a series of like judgments; (i) The second test of the series are judged better than any others.

II. Some Introspective Observations. (a) The judgments in tests on 100-gram weights seemed to be based quite exclusively on mere touch-sensations; (b) The judgment seemed to be based more on the changes in stimuli that occurred at the beginning of the lift, than on any constant sensations after the weight once cleared its base of support. The best results were obtained by directing the attention to the first sensations. Swinging the weight up and down did not seem to improve the discrimination much, if any; (c) The accuracy of judgment varied greatly, sometimes even with no apparent cause; (d) Very quick and very slow lifts were hard to judge; (e) In lifting the large weights the judgment seemed to be based principally on "muscular sensations;"[1] (f) Very small increments make judging very fatiguing by their great demands on attention; (g) One can distinguish quite noticeably when lifting very large weights, that he is beset with a focal[2] sensation, and with numerous marginal sensations, some having only a distracting influence upon the attention, such as noises, heat, the pains from uncomfortable positions, and muscular pains; and others, that must be regarded as auxiliary sensations to the focal sensation. They, with the focal sensation, figuratively, in a heap, constitute the real basis of discrimination. Among these marginal auxiliary sensations the following were pronounced: (1) Touch sensations around the grasp; (2) Pressure sensations; (3) Changes in the pressure of the back against the back of the chair; (4) Increased pressure on the seat of the chair; (5) Feet pressing more firmly on the floor; (6) Other hand putting forth effort wherever it may be placed; (7) Interference with breathing; (8) Interference with circulation; (9) Intercostal and abdominal muscular sensation.

Some of these may pass over and become sources of distraction rather than auxiliary sensations.

Hypothetical Considerations.

The following hypotheses are based partly on the data determining the curve given in the first part of the paper, and partly on the introspections noted as the experiments were being made.

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[1] Sensations based on specific sense-organs in muscles, tendons, joints, and all of the accessory organs of movement. Schäfer's Text-Book of Physiology, Vol. II, 1006. Macmillan, New York, 1900.

[2] By *focal sensation*, it is intended to designate one toward which the mind is primarily directed.

Basis of Judgment.

In stating the basis of judgment for lifted-weights it is convenient to divide the field of sensations into two classes, focal and marginal. When weights are being lifted the focal sensation is usually, though by no means always, the sensation for which the stimuli change most vividly.

Besides this focal sensation there are many marginal sensations in consciousness down to a feather-edge in "subconsciousness." Some of these tend to draw attention away from the focus, and thus to induce poorer judgment: others seem to go along with the focal, to be auxiliary sensations, and by their presence to induce a finer discrimination.

These marginal auxiliary sensations are often very marked where hardly anticipated. When conducting some tests where the reagent lay on his side on the floor, several judgments with the larger standards were rendered with the attention fixed upon the tendency to slide along the floor in the opposite direction from the pull that was being made. Surprisingly enough the feeling of assurance and the correctness of the decisions were quite as good as when the attention was directed to the muscular sensations of the arm. But the fact of these marginal sensations does not prove that any of them are auxiliary in forming the judgment.[1] Jastrow and Bruce bandaged the arm tightly so as to empty most of the blood, and then rubbed the skin with ice. This greatly reduced the sensibility of the skin, but did not affect the judgment for lifted-weights. (Letter to the writer.) Here subtracting some of the marginal sensations did not affect the judgment.

"According to the law of perception[2] of weight by the sense of cutaneous pressure alone, it requires the addition of one-third of the original weight, whatever it may be, to produce a distinctly perceptible difference; but in Bernhardt's experiments on the foot it was found that the addition of from three to five Loth (1½ to 2½ oz.) to an original weight of from a pound to a pound and a half could be distinctly perceived, which is less than one-half of the increment perceptible by cutaneous pressure alone.

In regard to the discrimination of weight by the finger, the sensibility was found to be much finer. Three drachms could be distinctly differentiated from nothing, and to heavy weights (say 1 pound) the addition of five drachms was dis-

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[1] Pierce and Jastrow (Memoirs of the Nat. Acad. of Sci., III, 1884,) showed that even the mere guesses on small differences fall according to law predominantly on the side of right judgments. Thus it appears that the subconscious states are factors that must be taken into account in judgments.

[2] Ferrier: Functions of the Brain, p. 391.

tinctly perceived, *i. e.*, a difference of about 1/16, a power of discrimination which corresponds pretty nearly with that of the muscular sense, which is capable of detecting an addition of 1/17 of the original weight. These results, therefore, indicate that the discrimination was much finer than could be effected by the sense of pressure alone, and that, therefore, it depended on muscular discrimination."

It seems that the presence of marginal sensations on which, singly, a fair judgment could be based, and all of which are induced by stimuli from a single source, within normal limits, should increase the accuracy of judgment. The presence of such a sensation may decrease the nicety of judgment of the focal sensation. But still it would have to be shown whether the decrease in the focal sensation is not more than compensated by such a marginal sensation as described above.

In whatever position one may be when he makes a lift the auxiliary marginal sensations are present. They vary greatly as larger standards are used. With their cumulative influx, up to certain limits, they probably increase the acuteness of discrimination. When very great, however, they may become sources of distraction.

With the very small weights the marginal consciousness is very limited in extent. Until a given degree of motion or tendency toward it is reached at any sensitive part of the body, no sensations result. Some organs and processes are disturbed earlier than others as the scale of weights is ascended. Hence, this gradual increase in the extent and intensity of the marginal consciousness. So it happens that, as the scale of standards is ascended, new marginal sensations keep coming in and rising higher and higher in consciousness. Some of the marginal sensations may become so strong as to take over the focus to themselves. And this is just what appears to happen, the muscular sensations which are at first marginal, later, become focal, and with the very heavy weights, sources of distraction, while the dermal sensations become marginal. Biedermann and Löwit found that the dermal sensibility to pressure decreases very rapidly above 450 grams. At 450 the least observable difference was 1/69, and at 500 grams it was 1/20 of the standard weight.[1]

This influx of marginal sensations, and transposition of focal sensations, from the tables and from the introspective observations, seems to have been most marked at from 800 to 1,200 grams. At 2,800 and 3,200 breathing and circulation were quite perceptibly disturbed. With the very large weights the

[1] Hering: Sitzungsber d. Wiener, Akad., LXXII, 342. Ladd's Physiological Psychology, 368.

sensations of strain about the shoulder, chest and abdomen may become focal.[1] With the latter weights also came certain marked distractions, as, muscular-pain from the heavy lift, and an unavoidable trembling of the arm.

It is probably entirely impossible to isolate completely these various sources and bases of judgment so as to determine the comparative worth of each for various standards, and within what limits Weber's, Fechner's or any other law holds. It may be that some law holds for each of the several bases after it becomes a factor in the discrimination, probably Weber's, but that no law has been or, possibly, can be formulated to apply to the sum of them.

Views of experiments are not wanting on the subject. G. E. Müller has called attention to the probability of a gradual influx of additional sensations.

With the larger weights come first muscular sensations with the upper and fore arm; and with very large weights, from the muscles of the chest and shoulder. One must ask, then, to what extent Weber's law is valid. The lifted arm may be a part of the lifted weight. To determine the validity of the law one must know whether any, or part, or all of the arm goes in with the given weight to make up the weight on which we really base our judgments. Moreover, the antagonizing force of the opposite and adjacent muscles cannot be known.[2]

Hering, long ago in a letter to Fechner, pointed out the probability of a complex of sensations as the basis of judgment.

"At the same time," says Bastian,[3] "a number of impressions emanate from the back of the hand, which, so far from aiding him in his judgment, would be a source of mental distraction. Then I would say, also, that, in estimating such weights as Weber employed, the person would almost certainly have experienced sensations emanating from the muscles themselves; and there is really no reason for believing that these sensations, derivable from a muscle which is contracting somewhat strongly, do not reveal themselves to us by means of ordinary sensory nerves in the muscles. I believe that they are due to the common sensibility of the muscle testifying to its own organic conditions, and that these sensations may well be part components of the impressions by which we are enabled to judge of differences of weight. And if this be the case, then it was to be expected, as I think, that there should have been a much greater power of discriminating differences of weight when the common sensibility of muscle was allowed to act in conjunction with the tactile impressions, than when these latter

[1] Ferrier's Function of the Brain, p. 392.
[2] G. E. Müller: Grundlegung der Psychophysik, p. 202.
[3] Brit. Med. Jour., XIII, 1869, 439.

were appreciated alone and apart from all distracting influences." He holds the muscular sense, however, to be only a fraction as delicate as the pressure sense.

We note that our view does not agree with Ferrier's[1] which seems to set aside all joint, tendon and purely muscular sensations in the arm. He says, "I am of the opinion that the discrimination of heavy weights calls into play the general sense of effort, which, as we have seen, is the more properly ascribed to the region of the respiratory muscles, and that the discrimination in this case is affected by the amount of bodily strain and fixation of the muscles of the chest necessary to support a heavy weight; and that it is not a question of the muscular sense of the limb at all, unless general strain is absolutely eliminated by continuous and easy respiration during the trial. When this is eliminated it will be found that the sense of local resistance is the only element in the discrimination of weight."

Weber considered that the reason for finer judgment in lifting, over that of mere pressure, was due to the muscular sense coming in as a further basis of judgment.[2]

The above views, except Ferrier's, seem to tally with the writer's introspections which may be restated briefly thus: Judgment of weights is based on focal and auxiliary marginal sensations, which change greatly as the scale of weights is ascended. The focal sensation changes from dermal to muscular, but may be voluntarily placed elsewhere; the marginal group constantly increases; and some sensations pass from auxiliary to distracting sensations.

In lifting a weight there is probably a normal rate of change in sensations at which the total amount of change can be judged most accurately, varying, to be sure, with different reagents. Change may be either too rapid or too slow for accurate judgment. J. S. Lemon[3] states that great pressure can be made without producing consciousness of the fact, providing that it be applied very gradually. Fontana, showed that a slight pressure on a nerve might be increased gradually until the nerve was crushed, without producing motion in the corresponding muscle. Heinzmann[4] and Fratscher[5] boiled reflex frogs without sensation enough to produce motion by applying the heat very gradually.

Very rapid changes make strong sensations, but sensations lacking nicety for distinction. Fullerton and Cattell,[6] on the

[1] Functions of the Brain, 392.
[2] Living Age, XIII, 12.
[3] Skin Considered as an Organ of Sensation: Whiting, and Whittaker, Gardner, Mass., 1899.
[4] Archiv. f. die gessammte Physiol., VI, 1872, 222.
[5] Jenaische Zeitschrift, I, 1875, 130.
[6] Perception of Small Differences, p. 131.

basis of a few experiments, held that the rate of lift does not increase the probable error. In changes of pressure it is claimed that the more rapid the changes the greater the accompanying distractions.[1]

It is precisely this change of sensations, occurring from the beginning of the lift until the weight clears its support, that we compare and judge, rather than the totality of sensation after the weight is up. The reagent will judge best when the speed and other conditions are most favorable for his taking these changes into full consciousness. If the normal speed is maintained, the height of the lift is of but little consequence, providing the reagent holds firmly to the changes which occurred at the beginning of the lift. But when the reagent defers judgment, he is liable to question his impressions and do little more than guess. Even when judgment is not at once declared and dismissed, one is apt to conclude that his impressions may have been in error. Moreover, the pressure, and probably other sensations, decrease rapidly after the application of the weight.[2] From our standpoint the basis of judgment appears to be the memory of a former change of sensation as compared with a present changing sensation.

The notion that the judgment is based partly on the sense of effort we pass by. The sense-of-effort view has been pretty generally abandoned.[3] If sense of effort exists at all it may be said to assume the relation of marginal sensation. Neither does it appear, with this apparatus, which picks up the weight more gradually than does Fechner's and Müller's apparatus, that the speed of the lift is so important as Müller and Schumann[4] found it to be. The speed, here, appears to be but one of the marginal sensations.

Interferences of Sensations.

Judgments of sensations are disturbed by two kinds of sensation-interference: (1) distraction, and (2) fusion. Distraction through sensations occurs whenever sensations arise which tend to draw the focus of attention to themselves, and thus away from any sensation or group of sensations which one is trying to judge. Interferences of this kind have been referred to at various places in this paper, and, for our present purposes, do not need to be discussed further here. This kind of interference has been pretty generally recognized, and has been studied rather extensively. Distractions arising

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[1] Hall and Motora: *Amer. Jour. of Psychol.*, I, 87.
[2] Psychol. Rev., Sup. I, p. 30.
[3] Schäfer's Text-Book of Physiology, II, p. 1002.
[4] Pflüger's Archiv., XLV, 36-112.

30. HAUGHTON, S. The relation between the maximum work done, the time of lifting, and the weights lifted by the arms. Proc. Roy Soc. of London, XXX, 1880, 219-224.

31. HENRI, VICTOR. Revue générale sur le sens musculaire. L'année psychol., V, 1898, 399-588. References, 391. Degrés de tension, 440-452.

32. HERING. Zur Lehre von der Beziehung zwischen Leib und Seele. Sitzungsb. d. Math.—phys. cl. d. k.—Bayer. Akad. d. Wissensch. zu München, 1875, Bd. LXXII. Alath. 3, S. 342. Experiments with eleven weights ranging from 250 to 2,750 grams.

33. HITZIG, E. Ein Kinesiästhesiometer nebst einigen Bemerkungen über den Muskelsinn. Neurol. Centralblatt, Mai. 1 and 15, 1888. It contains a short discussion of lifted-weights with the foot, and a discussion of joint-sensibility.

34. HUBER AND DEWITT. Motor nerve-endings and nerve-endings in the Muscle-spindles. Jour. of Comparative Neurology, Vol. VII, 1898, 169-230. (39 figures; 85 references.)

35. JACOBY. Untersuchungen über den Kraftsinn. Arch. f. exper. Path. u. Pharmakol. Leipzig, 1893, XXXII, 49-100. He used a long range of weights.

36. JACCOUD. Les paraplégies et l'ataxie du mouvement, 665-672. Paris, Adrian Delahaye, 1864, 672. Reviewed by Bastian in Brit. Med. Jour., May, 1869. He experimented with 24 ataxic patiente, lifting with the foot, with weights weighing from 100 to 3,000 grams.

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38. JASTROW. A Critique of Psychophysic Methods. *Amer. Jour. of Psychol.*, 1887-8, 271-309.

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PSYCHOLOGICAL LITERATURE.

Examen psychologique des animaux. Nouvelle méthode expérimentale de classification des espèces au point de vue psychologique. Par PIERRE HACHET-SOUPLET. Paris, Schleicher Frères, 1900. pp. xvi-162.

The author of this interesting book points out that comparative psychologists have missed the most natural and fruitful method of studying animal minds, in that they have failed to appropriate and use systematically for scientific ends, the procedure employed by professional trainers for practical ends. The book in question presents the results of a limited application of this method; but for completeness and certainty, such work needs to be done in connection with great zoölogical gardens. M. Hachet-Souplet announces an understanding with the authorities of the *Jardin d'acclimation*, which makes the realization of his project of a great zoölogical laboratory, where such systematic study may be carried on unlimitedly, only a matter of time. Certainly much is to be hoped for from the adoption and application by psychologists of the methods of testing animal intelligence in this large and free, and at the same time, strictly experimental way. Suggestions of a like tenor, but much less comprehensive, have been made by Professor Lloyd Morgan; of which, however, M. Hachet-Souplet appears to be ignorant.

Inasmuch as the minds of animals vary independently of morphological characters, the author demands a new classification of species based strictly upon psychological characters. This demands study of animal minds on their own account, absolutely free from morphological leading strings. It will be time enough to reconcile the morphological and the psychological classifications after each separately has been made out with some degree of completeness. The psychological criteria are: what does the animal do under given conditions, and what influences does he respond to. Upon the basis of his somewhat wide and varied employment of the *méthode de dressage*, the author proposes a tentative scheme of classification embracing types of most of the morphological categories. This scheme consists of three categories: animals whose sole psychic attribute is excitability; those subject to coercion; those subject to persuasion. The first category is self-explanatory, and includes only the protozoans. The second category contains those animals possessing primitive instincts—nutrition, reproduction, and conservation (*défence*)—and functional memory, *i. e.*, memory connected always with some bodily function. The animal perceives, in the external world, the conditions of satisfying the primary instincts; but this consciousness is strictly connected with the return of functional need, and leaves no independent image in the nervous organism. There are two sub-categories based upon the relative complexity of the functional memory. This category includes animals as widely variant as Medusa and deer. Training is by *coexcitation*, *i. e.*, by modifications of external conditions or fear—whereby the *sûrs instincts* are readapted.

The third category contains all the higher animals. They possess *intelligence*: *i. e.*, their brains are capable of preserving impressions of *perceptions* independent of immediate functional needs. Such an

animal is like a closed vase in which ideas develop, jostle each other, and combine. The result of the jostlings and combinations is a *détermination*, in the sense of the domination in consciousness of one or other of the ideas. In animals, as in man, this gives the illusion of choice and free intelligence. Animals in this category are capable of being persuaded, *i. e.*, of conceiving cause and effect as man conceives them. They understand when man seeks to show them by "*une mimique expressive*," the relation of cause and effect. Such mentation M. Hachet-Souplet thinks he has demonstrated in some of the higher animals. There are three sub-categories, dependent upon the degree to which the animals are subject to persuasion; and upon the presence of secondary (acquired) instincts. He is a warm partisan of the "lapsed intelligence" theory, and thinks the thesis easily demonstrable by his method of investigation. This category includes types as remote as the ant and the chimpanzee. To the higher animals are attributed imagination, abstraction, æsthetic sense, personality and other high mental powers. These attributions, however, are made guardedly and on the basis of experiment; not at all in the loose manner of Romanes, whom M. Hachet-Souplet constantly criticises.

The obvious strictures upon the book are: the somewhat superficial character of some of the psychological analysis; the ignorance or disregard for some important recent work in animal psychology—there is no mention of Morgan, Thorndike, Bethe, Wasman, Peckham *et al.*; and the fact that his zeal for the evolutionary philosophy (Spencer's) occasionally carries him, in his interpretations, beyond his facts.

Nevertheless, this book is a valuable and interesting contribution to positive comparative psychology—and, withal, brilliantly written.

W. S. SMALL.

Psychology, Empirical and Rational. (Stonyhurst Philosophical Series, No. 5.) By MICHAEL MAHER, S. J. Fourth edn., revised and enlarged. London, New York and Bombay. Longmans, Green & Co., 1900. pp. xxii, 602, xii. Price, 6/6.

In this new edition, the modifications up to ch. ix are slight, except that more space is devoted to physiology and psychophysics. Chs. xiv (origin of intellectual ideas), xvi to xix (attention and apperception; development of intellectual cognition; rational appetency; free will and determinism), xxii (false theories of the ego) and xxiv (immortality of the soul) are almost wholly new; the supplement on hypnotism, and the criticisms of the theories of James and Höffding, appear for the first time. The historical sketches have throughout been substantially increased.

For the rest, the plan and scope of the work remain as before. Thomas Aquinas is the constant standard of reference; and, while the author does good service in calling the attention of scientific psychologists to authors with whom they are but little, if at all familiar, he has himself no adequate knowledge or appreciation of the course of scientific psychology.

E. B. T.

From India to the Planet Mars: a Study of a Case of Somnambulism, with Glossolalia. By TH. FLOURNOY, Professor of Psychology at the University of Geneva. Translated by D. B. Vermilye, New York and London; Harper Bros., 1900. pp. xx, 447. Price, $1.50.

The original of this translation was reviewed in the *American Journal of Psychology* for April, 1900 (Vol. XI, pp. 428 ff.). As, however, the book is attracting much attention, both from psychologists and from the general public, and as its contents will strike different readers very differently, I take the opportunity afforded by the appearance of

an English edition to say a few words about the remarkable case of automatism described in its pages.

The subject of the memoir is, as is well known, a certain 'Mdlle. Hélène Smith,' an unmarried woman of about thirty-five years of age, "earning an honorable living as an employee of a commercial house." M. Flournoy has been at great pains to gather data concerning 'Mdlle. Smith's' childhood and youth—wisely, since such data are of extreme importance for the understanding of her story. We learn that she was a child of somewhat dull intelligence, at least as measured by school standards (p. 18); that she was given to day-dreaming and reverie; that she was subject to occasional hallucinations; that she felt herself out of place in and superior to her family surroundings, so that she "one day seriously asked her parents if she was their daughter" (27), and her father and brothers were apt to rebuke her for pride; and that she was of a melancholy, timid, nervous disposition. "Hélène Smith was certainly predisposed, both by heredity [on the mother's side] and temperament to become a medium" (19). Nevertheless, she 'outgrew' these systoms of nervous disorder: the "tendency to mental disintegration, which marked the years of puberty, was succeeded by a progressive diminution of these troubles." "We may infer . . that the ebullitions of the imaginative subconscious life gradually became calm after the explosion of the period we have mentioned. . . A certain equilibrium was established between the necessities of practical life and her inward aspirations." "We may presume that this harmonization . . . . would in time have perfected itself, and that the whole personality of Mdlle. Smith would have continued to consolidate itself" (32 f.). In a word, if she had been left to herself, 'Mdlle. Smith' might have become a normal personality, and have been the healthy mother of commonplace children (32, 131). Fortunately or unfortunately, as the reader may choose, she fell (at about the age of twenty-seven) under the influence of some spiritualistic friends; "spiritism . . . . came all of a sudden to rekindle the fire which still slumbered under the ashes, and to give a new start to the subliminal mechanism which was beginning to grow rusty." This fact—the fact of the spiritistic manufacture of 'Mdlle. Smith's' mediumship—should not be overlooked.

Another point of interest is the following. It was "the age of puberty" in 'Mdlle. Smith' that "began to favor the development of the Oriental visions." Now the 'Leopold' of the revived subliminal imagination has his origin, in M. Flournoy's judgment, in the sexual coenæthesis of the medium. "He represents . . . . the synthesis, the quintessence,—and the expansion, too,—of the most hidden springs of the psychological organism. He gushes forth from that deep and mysterious sphere into which the deepest roots of our individual existence are plunged, which bind us to the species itself, . . and where confusedly spring our instincts of physical and moral self-preservation, our sexual feelings" (87). "The real and primordial origin of Leopold is to be found in that deep and delicate sphere in which we so often encounter the roots of hypnoid phenomena" (91). "He is not troubled about her general health. . . . . His attention is concentrated upon certain special physiological functions, of the normal exercise of which he takes care to be assured. . . . . He has for several years formally laid his ban upon every kind of mediumistic exercises at certain very regular periods" (133 f.). Leopold is thus the personification (and M. Flournoy offers a reasonable account of the building-up of his personality: 91 ff.) of "scruples more or less vaguely felt, certain hesitations or apprehensions, inhibiting feelings or tendencies,"—of "instinctive feelings and emotional tendencies,"

—characteristic, to some extent, of the feminine mind in general, but culminating in the present instance in "knowledge and prevision of the most intimate phenomena of the organism" and an unusually refined coenæsthetic sensibility. In the light of this analysis it is intelligible that, in her ordinary social relations, 'Mdlle. Smith'—apparently, whether she is under the immediate direction of Leopold or not—shows a modesty and reserve that amount almost to prudery (89 f., 28, 131). The sexual instinct finds its satisfaction—in an idealized and platonic way, but none the less really—in the occurrences of the trance-life (8; 115; 287 f., 289 f., 293, 341).

I have no intention of following M. Flournoy through his analysis of the three 'cycles,' the Martian, the Hindoo, and the Royal. He has done his work with extreme patience and acumen. Indeed, when one remembers the almost infinite possibilities of suggestion to which 'Mdlle. Smith' has been exposed on the confines of her trances (a point sufficiently emphasized by the author: 49 ff., 93, 146, etc.), one marvels at the high measure of success in explanation that M. Flournoy has attained. Few psychologists will dispute his conclusion that the 'secondary personalities' "do not exist outside of Mdlle. Smith," but have their genesis within her mental life. And even those who, like the present writer, have no great affection for the 'subliminal self,' but rather believe with Galton that the terms 'individuality' and 'personality' are apt to be psychologically misleading,—even they will readily admit that M. Flournoy's methodical study proves the high value of subconscious imagination as a working hypothesis. As for the outcome of the author's study of the 'supernormal,'—"I believe I have actually found a little telekinesis and telepathy [though the appearances of lucidity and spiritistic communication are explicable in terms of the hypnoid imagination],"—the critic can only note that his attitude to the phenomena is rather that of "I can't disprove the things: let them rest for further investigation" than that of positive acceptance (381; 389; 396, 401; 407, 13; 424; 445).

In his conclusion, M. Flournoy lays just emphasis upon the difficulty of the "neuropathological problem of mediumship." "To endeavor to fix the connections of mediumship with other functional affections of the nervous system, it would first be necessary to possess exact intelligence on a number of important points still enveloped in obscurity." We must understand "the phenomena of periodicity, of meteorological and seasonal influences, of impulses, and of fatigue;" "the relations of equivalence and substitution between the various modalities of automatism;" "the effect of spiritistic seizures, and especially of that of the seances, upon nutrition and denutrition (variations of temperature, of urotoxicity, etc.)." These are wise words; and one can only express the hope, with the author, that "a near future will establish some good mediums and their observers in practical conditions favorable to the elucidation of these various problems, and that the day will come when the true place of mediumship in the framework of nosology will be discovered" (441 f.).

The translation, save for a few slips due more to hasty work than to misunderstanding, seems to be accurately made. Unfortunately, Mr. Vermilye cherishes the conviction—surely erroneous—that any phrase in the English language, however constructed, can be grammatically added to any other phrase by means of the magic connectives "and which." The application of this principle—which, on M. Flournoy's model, may be termed the principle of Mrs. Sarah Gamp—leads to sentences like the following (italics mine). "The spontaneous phenomena of this category . . . . can be subdivided into two classes, according to their direct attachment to the personality of Leopold, or

their not belonging to any distinct personality, *and which* only express in a vivid manner the result of the normal working . . . . of the faculties of memory and of reason" (58). But, if the translation has faults of style, the translator's Preface adopts a tone which is simply inexcusable. To suggest that "the scientific investigation of psychic phenomena may succeed in proving *the preamble of all religions*" (ix) is to put the prospective reader in a frame of mind the very opposite of that which the reading of the book demands, and which the writer of the book desires. Future editions of the work should be supplied with an index. E. B. T.

L'année psychologique. Publiée par A. BINET, avec la collaboration de H. BEAUNIS, TH. RIBOT, etc. Sécrétaire de la redaction, V. HENRI. Quatrième Année, 1898, pp. 849; Cinquième Année, 1899, pp. 902. Paris: Librairie C. Reinwald; Schleicher Frères, Editeurs.

These two volumes amply sustain the reputation that their predecessors have won for M. Binet and his coadjutors. Vol. IV opens with an article by MM. Binet and Vaschide upon psychology at the primary school. This is followed by seventeen papers, from the pens of the same authors, dealing with the measurement of muscular strength, respiration, etc., of school children. A critique of the oval hand-dynamometer and of the Mosso ergograph will be extremely useful to the experimental psychologist. M. Binet then contributes three essays upon topics akin to those mentioned, and M. Vaschide writes upon the influence of prolonged intellectual work upon the rapidity of the pulse. M. Bourdon discusses the application of the graphic method to the study of the intensity of the voice, and the results of recent investigations of the visual perception of depth. M. Leclère's "Description of an Object" is an interesting piece of individual psychology.

In Vol. V, M. Joteyko gives a 'revue générale' of muscular fatigue, and M. Henri of the 'muscular' sense. M. Binet writes on suggestibility, as a factor in individual psychology; and this author, with MM. Henri and Larguier, deals again with the questions of intellectual work and its measurement. There are, further, articles by M. Bourdon, on horizon illusions; by M. Clarapède, on stereognostic perception; by M. Clavière, on colored hearing; by Professor Zwaardemaker, on olfactory sensation; by M. Marage, on the phonographic study of vowel sounds and on cephalometry; by M. Blum, on paidology; by M. Larguier, on dynamometry; by M. Demeny, on chronophoto-...ic apparatus; and by M. Manouvrier, on anthropological cepha-... A good and varied programme!

...volumes contain, besides these original articles, abstracts and ... of the most important publications of their respecive years, ...plete bibliography.

...ychologique, publiée par ALFRED BINET. Sixième Année. ...her Frères, Paris, 1900. pp. 774.

...t welcome volume differs from its predecessors in giving ... pages to original articles, three of which are by Binet, and ... are interesting and valuable.

...ography itself occupies 130 pages, so that only 123 are de-...ual digests of a limited number of articles. These are so ...despite the excellence of the original contributions, many ...that more space was not given to this department of the

L'Évolution du droit et la conscience sociale. Par L. TANON, président à la Cour de Cassation. Paris, F. Alcan, 1900. pp. 166. Price, fr. 2.50.

All legal rules and institutions have been determined, on the one hand, by utility and the conditions of living, and on the other by the successive stages by the developing social consciousness. The term "common good" is that which best covers the facts; it enables us to oppose to the principles of "natural law" a positive conception, of legal value, and according with the data of history.

David Hume, moraliste et sociologue. Par G. LECHARTIER. Paris, F. Alcan, 1900. pp. 278. Price, fr. 5.00.

Hume's work has at least the negative value of combating the exaggerated pretensions of the speculative reason. But it also forms a positive propædeutic to a true philosophy. M. Lechartier opens his book with a brief biography of his subject. Then follows an account of the ethical problem before Hume, whose own contribution to philosophy is considered in two chapters, under the titles of *Philosophie théorique* and *Philosphie pratique*. The volume concludes with a translation of "A Dialogue."

Leitfaden der physiologischen Psychologie, in 15 Vorlesungen. Von TH. ZIEHEN. Fünfte, theilweise umgearbeitete Aufl. Jena, G. Fischer, 1900. pp. v, 267.

The text of this fifth edition differs only in minor points from that of 1898. The references have been brought up to date, and four new cuts appear (Fig. 7, section through a *Papilla foliata* of a rabbit; Fig. 12, schema of the structure of the organ of Corti; Fig. 13, schema of the structure of the retina; and Fig. 23, schematic representation of the affective tone of an idea). Fuller treatment is accorded to the process of Recognition in Lect. X. By the use of a somewhat smaller type, the book has been kept down to its former size.

Mind and Body. By A. BAIN. pp. 49. Price, c. 15.

Illusions of the Senses. By R. A. PROCTOR. pp. 41. Price, c. 15.

Hypnotism: its History and Present Development. By F. BJOERNSTROEM. pp. 126. Price, c. 30.

Body and Mind, with Other Essays. By W. K. CLIFFORD. pp. 47. Price, c. 15.

Mental Suggestion. By. J. OCHOROWICZ. pp. 96, 369. Price, $1.20.

Nos. 13, 82, 113, 145, 152-8 of the Humboldt Library of Science. New York; The Humboldt Publ. Co., 1880-92.

We are glad to call the attention of our readers to the psychological volumes of the Humboldt Library. The parts are published in pamphlet form, with a page of about 23 by 15 cm. The earlier numbers were printed in double columns and (apparently) from photographic films: the text is small and broken. The later volumes have a single-line page, and the text is clear and good. In supplying a book like Clifford's "Essays" in this form and at this price, the publishers have deserved well of the psychological community.

Sensation et Mouvement, Études expérimentales de psycho-méchanique. Par CH. FÉRÉ. Deuxième édition, revue. Paris, F. Alcan, 1900. pp. 170. Price, fr. 2.50.

The first edition of this well-known little book was published in 1887. The text has now been revised, and minor changes in expression made at various points, while new notes and references have been added.

Questions de Morale, Leçons professées au Collège libre des Sciences sociales. Par G. BELOT, M. BERNÈS, F. BUISSON, A. CROISET, V. DELBOS, A. DARLU, E. FOURNIÈRE, P. MALAPERT, G. MOCH, D. PARODI, G. SOREL. Paris, F. Alcan, 1900. pp. vii, 331.

The ethical addresses delivered at the Collège libre des Sciences sociales in 1899 were collected in a single volume, under the title *Morale sociale.* Encouraged by the success of this book, the Council of Direction now issue the addresses of 1900, as Vol. VIII of the Alcan Library of Social Science. Twelve lectures are printed in full. M. Sorel writes on science and morality; M. Moch on the subject of the book prepared by him in collaboration with M. von Egidy,—'L'Ère sans violence;' M. Darlu on Christian ethics and the consciousness of to-day; M. Sorel, again, on the moral factors in evolution; M. Delbos on Kant and the science of ethics; M. Croiset on Greek ethics; M. Bernès on the conditions of action; M. Parodi on reason and instinct in morality; M. Belot on luxury; M. Fournière on Guyau's ethics; M. Malapert on social justice; and M. Buisson on moral and religious education. The volume contains, further, abstracts of the addresses delivered by MM. Boutroux and Croiset on the opening of the School of Ethics, Nov. 27, 1899.

Über Psychologie der individuellen Differenzen (*Ideen zu einer Differentiellen Psychologie*), von L. WILLIAM STERN. Schriften der Gesellschaft für Psychologische Forschung. Leipzig, Verlag von Johann Ambrosius Barth, 1900. pp. 144. Price, M. 4.50.

The book is a valuable and needed résumé and critique of the work already done in a subject which has grown up in its present form as a protest against the indiscriminate massing together of the results of psychological experimentation, and an examination of its aims and methods. It is divided into three parts, the first treating of the nature, tasks and methods of differential psychology; the second of some of the fields of mental differentiation and their experimental investigation; and the third devoted to a select bibliography of the subject. The author's exclusion from the bibliography of a mass of more or less available material was doubtless due to the necessity of curtailment on account of lack of space. Practically a complete bibliography of differential psychology would be a bibliography of experimental psychology.

Chap. I of the work discusses differential as opposed to general psychology, psychological types, individuality, the normal and abnormal. As regards terminology, the name "differential psychology" is preferred to that of "characterology" (Bahnsen), "Ethology" (Mill) or "individual Psychology" (Binet, Henri, Kräpelin, and others). "Characterology" and "Ethology" are considered too narrow. "Individual psychology" is already employed with another meaning as opposed to folk and social psychology. Chap. II reviews the methods of differential psychology: introspection; observation; the psychological studies of history and poetry (where observation is directed upon secondary sources), and of the evolution of culture, the questionnaire or census method (*Massenprüfung, Enquête*), and experimentation. He thinks the questionnaire method should be used with the greatest possible care, and that the *Prüfling* (he prefers this term to reagent or *Versuchsperson*) should be, if possible, a trained psychologist. The author seems, however, quite to overlook the suggestive value of the questionnaire in opening up new fields of investigation. Under the method of experimentation, the author discusses what a "mental test" is and declares that an hour and a half, as given by Binet and Henri to the testing of the memory, imagination, attention, etc., of a

single individual is entirely inadequate, a point that may be regarded as well taken or the reverse according to the purpose for which the examination is made. Chap. III treats of natural ability to distinguish and of active sensibility. Here the question as to whether individual differences rest upon sensation or the higher mental activities is taken up. When one remembers the significance of this question as regards the extraordinary powers exhibited by certain individuals in a given direction, one regrets with the author that Binet and Henri did not demonstrate their formula "the higher the psychical function, the greater the individual deviations," by experiment, although there is perhaps sufficient empirical material already at hand to justify the tentative use of the formula. Chap. IV takes up the determination of the general perception type and the formal perception type, meaning by the latter the type as regards the perception of time and space relations. Chaps. V–VII are devoted to the excellence of the memory and the differentiation in memory content; to association; and to apperception types. Chap. VIII deals with continuous and momentary distraction of the attention, with distractability and energy of attention, and with distractability and soundness of sleep. The topics of Chaps. IX–XII are: ability to make combinations; definiteness and reliability of the judgment, suggestibility of the judgment, subjective and objective types of judgment; reaction types; and the feelings. In Chap. XIII (on Psychic Tempo) the author reports the results of some preliminary experiments which go to show that each has a time in which he naturally acts and reacts. In Chap. XIV day and night curves of psychical energy and the characteristic quality of work are considered. Like so many German books, this book would be much increased in value by an adequate index. LILLIE J. MARTIN.

Prison Laboratories. By C. R. HENDERSON. American Journal of Sociology, Nov., 1900. pp. 316-323.

The author embodies the report of a committee appointed in 1899 by the National Prison Association "to consider the wisdom of establishing laboratories in a limited number of prisons." The committee reported favorably, recommending laboratories which shall be permanent, under the control of well-trained experts, with the practical motive of studying the personal, hereditary and environmental influence of the prisoners. Records are to be kept of body measurements, mental activity in attention and perception, in making associations, comparisons, and in reasoning, a work which has not been done heretofore. It is hoped that if the causes of crime are not found, at least a means of its amelioration may be. EZRA ALLEN.

Individual Tests of School Children. By E. A. KIRKPATRICK. Psychological Review, VII, 1900, 274-280.

In studying tests of general mental ability Professor Kirkpatrick has discovered that the study of 500 children of grades 1-8 for keenness of sensory-motor reactions showed that the curve rises to the sixth grade or so, and then remains stationary, or declines. He infers that there must be different tests for different stages of development, and that quick reaction in these matters may be no criterion of general ability in college students. M. F. LIBBY.

The Old and the New Magic. DR. PAUL CARUS. Open Court, Vol. XIV, 1900. 333-348, 422-437.

The old magic sought to transcend human knowledge by supernatural methods, by the assistance of invisible presences. This idea, strong in the Middle Ages, still exists. In primitive society religion is magic. The manhood of man is to be gained by science through

the conquest of all magic. Magic as superstition is doomed. As art it will live. A knowledge of conjuring tricks is desirable, and the author advises its communication in the education of children.

In the observation and detection of magical tricks scientists are likely to err widely. Prof. Zöllner failed to notice the trifling acts of the medium, which were really the important things. The psychological problem in the case of the extravagant tales of the wonders of foreign magicians is as to the state of mind of the narrator. The triviality of a number of these tricks are shown. The article is a good popular presentation. NORMAN TRIPLETT.

The Modern Occult, by PROF. JOSEPH JASTROW. Pop. Sci. Monthly, Sept., 1900.

The author shows the relation of the modern occult to ancient occultism, and discusses the present-day phases of Theosophy, Spiritualism and Christian Science, with a passing mention of Alchemy, Astrology, Phrenology, Palmistry and Divine Healing. Christian Science, so-called, is perhaps calculated to exercise a wider influence than the other cults.

The reason for the development of these occult beliefs are: ignorance, a somewhat feeble cast of mind that does not perceive the errors of false logic, and tends naturally to superstition, and an undue anxiety concerning one's own personality. The antidote lies in the diffusion of exact knowledge. MARGARET K. SMITH.

La psychologie de 1899 à 1900, par TH. RIBOT. Revue scientifique, T. XIV, 353-356. Sept. 22, 1900.

In this presidential address before the recent Psychological Congress *Ribot* reviews Psychology from 1889-1900. In 1889 the interest was chiefly in hypnotism, mind-reading, etc.; in 1892 in psychophysics, nervous system, and exact experiment; in '96 in *everything* that could help in any way; psychophysiology, psychology of normal and abnormal persons, and comparative psychology. In 1900 we begin to find that the psychologist must *interpret* what the neurologist and physiologist discover. In memory and association good work is being done in study of children and unconscious association, the latter amid keen controversy. The study of attention and motor and sensorial reactions tends to show that reactions depend on individual constitution. Whether attention increases intensity and clearness of representations is still doubtful. He hopes for more theses on the emotions, and on complex processes generally, such as reasoning and imagination. Accuracy can be got, by a firm empirical basis in art, anthropology, linguistics, etc. Sound work is being done in genetic pyschology on this basis, and much may be hoped in psychology of character, and of the tribe. Germans and Americans lean to psychophysics, French and Italians to abnormal psychology, and English to introspection. We do not at present want general outlines of psychology so much as monographs. M. F. LIBBY.

La question des méthodes en psychologie, par M. GUIDO VILLA. Revue scientifique, T. XIV, 357-362, 22 Sept., 1900.

In this Villa discusses methods in psychology. He also advocated freer scope in handling the vast subject matter of human and animal history from the point of view of psychology, and praised the American methods as illustrated by the non-mathematical yet empirically-grounded and scientific interpretations of James and Baldwin, rather at the expense of the timorously accurate German methods, while admitting that the latter had overthrown the introspective literary dilettantism of the 18th Century. His whole argument is to the effect that

having learned the meaning of scientific methods of introspection it is time to move on toward interpreting the history of the human mind wherever we get facts about it, instead of confining ourselves to such facts about it as can be handled with mathematical precision.

M. F. LIBBY.

La Philosophie de H. Taine, par GIACOMO BARZELLOTTI. Tr. from the Italian by Auguste Dietrich. F. Alcan, Paris, 1900. pp. 448.

This is an exposition of Paine's philosophy and his method, and seeks to show that his genius was an eminent expression of the Zeitgeist, both intellectual and æsthetic, that as such his systematizations made not only for mental economy, but that his thoughts were the seats of other harvests.

Les Dilemmes de la Métaphysique Pure, par CHARLES RENOUVIER. F. Alcan, Paris, 1901. pp. 288.

The dilemmas are—the unconditioned and the conditioned, substance, the all or function of phenomena, the infinite and the finite, determinism and liberty, the thing or the person. These are all reduced to one alternative, to one thesis and antithesis, viz., being or non-being.

Grundzüge der Psychologie, von HUGO MÜNSTERBERG. Vol. I. J. A. Barth, Leipzig, 1900. pp. 565.

This volume is dedicated to the author's "dear colleague in Harvard University. William James, in sincere reverence and heartiest friendship." This general part, which deals with the principles of psychology, is to be followed by a special part treating the facts. The first part treats the principles of individual, and the second those of sociological psychology. We are promised that the whole will be no objective text-book restating the generally well known facts of the science for the writer's purpose is more subjective. The author will discuss rather than present; will sift out and connect rather than inform; so that from the rich manifoldness of the data, real and unitary features shall appear. His effort is, therefore, at the bottom philosophical. This is especially true of this introductory volume which is more or less complete in itself, treating of fundamental ideas, presuppositions, limitations and ideals of psychology. It is a book of war (Kampfbuch), which in an unphilosophical age takes up the gauntlet of idealism against naturalism. The positivistic view of the world, which has one of its strongholds in psychology, must be met, for it is striking its insidious roots into our social consciousness, education, art, ethics, and morals. It cannot be overcome by despising or denying empirical research. Three, and those perhaps the most important chapters, are essentially the same as in the author's Psychology and Life. His general position is a kind of synthesis of Schopenhauer, Fichte, and scientific psychology. As far as we have read the second and third parts, they are more or less implied in the author's English work. We hope, however, to recur to these more at length later, especially as the standpoint, which the author ably represents, is so radically different from the idealism to which the writer of this note no less fervently holds.

Text-book of Physiology. Edited by E. A. Schäfer. Vol. I, pp. 1036. Vol. II, pp. 1365. Young J. Pentland, Edinburgh; The Macmillan Co., New York, 1898 and 1900. Price, $8.00.

Professor Schäfer and his twenty co-laborers have here produced a monument to English physiology which, although less extensive than Hermann's Handbuch of twenty years ago, is no less well devised and representative. In comparing the two, one is struck by a progress

hardly less marked than that which separated Hermann from the old four volume Handwörterbuch of Wagner in 1846. While this work owes as all must very much to Hermann, it is a striking reminder of the great progress which physiology has made in the last two decades. Foster's first edition marked an epoch in physiology in English speaking lands, and was a marvel of individual industry and ability, but the field has distinctly outgrown the ken of any one representative, and henceforth every adequate presentation of what is embraced under the term physiology must be co-operative.

By this method the authors are enabled to present in precise form the contents of many hundreds of original papers which are referred to in the notes, so that for general purposes the necessity of referring to first sources is superseded, while for those who need to do so this work is facilitated. The enormous literary work involved in such a book is one of its striking features. The volumes are well supplied with indexes, the first volume having seventy-two and the second one hundred and four pages, while there are five hundred and forty-one cuts and many tables.

Psychologists will be especially pleased with the chapters on nerve, by Gotch; on the nerve cell and the cortex, by Schäfer; on cutaneous sensations and muscle sense, by Sherrington; on vision, by Rivers; the ear and vocal sounds, by M'Kendrick and Gray; and on the senses of taste and smell, by Haycraft. In most cases these later writers have well availed themselves of the experimental work of psychologists who, if they often find that articles they would like to see considered, have not been noticed as sometimes occurs, will not be too critical with a gift horse. Every working psychologist will need this book at hand until it is superseded by a better.

It is easy to criticise, but we cannot forbear expressing our regret that the subjects of generation and reproduction, as well as the physiology of the cell generally considered in such treatises, have been omitted, partly because the subjects involve morphological methods, and partly because they are so important that they would swell the size of the volumes unduly.

Diffusion of the Motor Impulse. WISSLER AND RICHARDSON. Psy. Rev., Jan., 1900. pp. 29-38.

In this paper experiments on arm muscles are described, having for their object the determination of the order of secondary contractions when the *abductor indices* and the biceps are respectively exercised by a series of movements. By means of tambours and kymograph, records of muscular contractions of two young men were obtained which show that when the motor discharge is directed to an extreme accessory muscle of the arm, diffusion is primarily to the muscle directly innervated and secondarily to adjacent related muscles in the order of their distance anatomically from the muscle innervated. The experiments also show diffusion to be downward as well as upward, and lead to interesting hypotheses respecting "cross education."

F. H. SAUNDERS.

Effets du travail de certains groupes musculaires sur d'autres groupes qui ne font aucun travail. KRONECKER AND CUTTER. Comptes Rendus, T. CXXXI, No 10 (3 Sept., 1900). p. 492.

This communication reports the results of experiments to determine the effects on the power of the biceps group of muscles of exercising the lower limbs in mountain climbing. The tests made after climbs requiring varying time and exertion clearly indicated in all cases gains in power in biceps muscles. The writers express the opinion that the effect is due to increase of circulation of blood or lymph.

F. H. SAUNDERS.

Heredity and Human Progress, by W. DUNCAN McKIM. G. P. Putnam's Sons, New York, 1900. pp. 283.

The dark side of human existence; the cause of human wretchedness; the defective classes; a remedy; and a consideration of objections against it, are the chief features of this book. The most striking and central idea is that artificial selection should help the elevation of the human race, partly by restricting reproduction by those organically very weak or vicious, and doing this, to use his language, "by the surest, the simplest, the kindest, and most humane means of preventing reproduction among those whom we deem unworthy of this high privilege" by "a gentle and painless death." "This should be administered, not as a punishment, but as an expression of enlightened pity for the victims too defective by nature to find true happiness in life, and as a duty toward the community and toward our own offspring." "The essential feature of the plan is the gentle removal from this life of such idiotic, imbecile, and otherwise grossly defective persons as are now dependent for maintenance upon the State, and of such criminals as commit the most heinous crimes, or show by the frequent repetition of crimes less grave, by their bodily and mental characters, and by their ancestry, that they are hopelessly incorrigible." "The majority of epileptics would require extinction; but those in whom the disease has apparently been caused by injury or by some removable condition, and whose families give indication of but little degenerative taint." "Respecting habitual drunkards, the degree of addiction to drink which should necessitate extinction would best be decided through a physical and mental examination," not in the quantity of liquor consumed in a day, nor in the duration of the habit. Criminals should be killed not so much for the injury dealt to society by any single act as their own dangerous quality. Murder is still the greatest crime, but here there should be discrimination. Nocturnal house breakers should be extinguished and all criminals who are idiots, imbeciles, epileptics, habitual drunkards, and insane, and all whose record in reformatory or prison shows them to be hopelessly irreclaimable. In every case the individual should undergo thorough examination, and his life should be taken only after due process of law. The method is not difficult. "In carbonic acid gas we have an agent which would instantaneously fulfill the need." To be sure, he says, the number of individuals is very great. In the United States there are now on the average thirty-eight murders a day, so that we live in the shambles, and this proportion is steadily increasing. About 14,000 of our fellow citizens die violent deaths annually. This might require a change of penal legislation, and even of some State constitutions, but "those who are shocked by the remedy here suggested, I would say that I too am shocked by it, but to be it seems a hard necessity laid upon us because our fathers failed to perceive their duty in this regard and to assume their proper burden."

The Life, Unpublished Letters, and Philosophical Regimen of Anthony, Earl of Shaftesbury. Edited by Benjamin Rand. Swan Sonnenschein and Co., London, 1900. pp. 535.

We have here a sketch of the life and the unpublished letters of the Earl of Shaftesbury, the English moralist, based on the Shaftesbury papers deposited in the Record Office in London. Fowler in his well known recent work on Shaftesbury and Hutcheson expressed the belief that these papers would repay more careful investigation than he was able to give them. The work entitled "Philosophical Regimen" (267 pages) discusses natural affection, providence, shame, reputation, friends, self, body, passions, pleasure and pain, character, maxims,

philosophy, and many other topics in a way so interesting that the editor declares that they contain "one of the most remarkable unpublished contributions of modern times in the domain of philosophical thought." His life is written by his son, the fourth Earl of Shaftesbury, and the second division contains his unpublished letters beginning at the age of eighteen up to his death, in 1713. The letters written to or about young men have a unique charm, while historians will welcome his political letters. His philosophy, as presented in "Characteristics," was largely stoical, but we have here a new and brilliant presentation of that system which shows how intoxicated he was with the idea of virtue. Indeed, since Marcus Aurelius, there perhaps has not been so strong an expression of stoicism as is contained in this "Regimen," now here published for the first time.

Fruitfulness, by ÉMILE ZOLA. Translated and edited by Ernest A. Vizetelly. Doubleday, Page and Co., New York, 1900. pp. 487.

This is a translation of one of Zola's most important stories, Fécondité, which may be of some interest to psychology. The writer was impressed with the diminishing natality in France, and here undertakes to characterize two families with their environment—one which was growing rapidly and with many children in its various branches; and the other, although more favorably situated, which was slowly dying out. It is all wrought up with his usual dramatic interest.

La Philosophie de Nietzsche, par HENRY LICHTENBERGER. F. Alcan, Paris, 1900. pp. 195.

The author has met a long felt want in giving us a comprehensive picture of Nietzsche's character, his intellectual emancipation up to 1878, his philosophy, most of which was written during the next ten years, and the positive and negative traits of his system. It also contains a convenient appendix and a bibliography—first, of all Nietzsche's writings, and secondly of the more important treatises on them.

Researches on Mimicry on the Basis of a Natural Classification of the Papilionidæ, by ERICH HASSE. Translated by C. M. Child. Erwin Nägele, Stuttgart, 1896. pp. 154.

The author goes through the butterflies and undertakes to describe each known case of mimicry in the various species and varieties. Although the work is technical and addressed chiefly to experts in natural history, its subject makes it of great interest to the general reader.

Liebe und Ehe und ihr Naturrecht, von RICHARD FUGMANN. Wilhelm Besse, Leipzig. pp. 128.

This book treats celibacy, chastity, monogamy, health, disease, who ought not to marry, hints for healthful marriage; and its motto is "chastity is the beginning of wisdom." It belongs to a large class of publications which may and may not do good, which are neither scientific or philosophical nor obscene, but which are sentimental, mystic and weak, and just enough risqué in title and content to tempt customers of a German railroad station news-stand. This journal has had, from time to time, about a dozen and a half books of this class that belong to the limbo where Kipling's Tomlinson found himself doomed, whom neither the good nor the bad place would receive. All are sure to quote or characterize briefly from Schopenhauer, Plato, Rousseau, Goethe, and perhaps Byron and Nietzsche. A small ingredient of their content is from Darwin, and they speak mysteriously of the morbid sex literature, but avoid its abysses. They poetize about true love and marriage, and the nameless horrors of certain diseases.

Die Transszendentale und die psychologische Methode, von MAX F. SCHELER. Dürr, Leipzig, 1900. pp. 181.

This interesting and timely work is a criticism of the transcendental method of considering space, time, personality, and cause, and the latter part is a statement by contrast of what he calls the psychological method. The former, he urges, can never solve the problems of philosophy. The noological method, which the author proposes, is based upon the fundamental ideas of work and consciousness. He declares that the latter cannot be considered as a product of development.

Interpretation of Poetry and Religion, by GEORGE SANTAYANA. Charles Scribner's Sons, New York, 1900. pp. 290.

The understanding, imagination and mysticism, Homeric hymns, the dissolution of paganism, the poetry of Christian dogma, platonic love and some Italian poets, the absence of religion in Shakespeare, the poetry of barbarism, Emerson, a religion of disillusions, the elements and functions of poetry are here treated. To this super-æsthetic and hyper-subtle mind, which is itself an exquisite illustration of the emasculating effects of an habitual atmosphere of epistemology. Browning and Whitman illustrate the poetry of barbarism; love is far more platonic than physical; belief at its best is a kind of poetry; and everything is falsetto and unreal. It would be difficult to find a better illustration of the devirilized effects of transcendental and idealistic habits of thought than in these pages, which are so chastened and refined that all vitality seems to have gone out of them. His is a world without color, where feeling, impulse and emotion merely cadence the forms of thought, and where the grasp on reality is so feeble that the whole has a charm that is supernal and afar. So bloodless a writer, whose mentality is so far removed from all storms of passion, and whose very beliefs lack fervor, from which all trace of spontaneity has long since vanished, seems to us a good illustration of decadence, but if so, degeneration never had a greater charm.

Education and the Philosophical Ideal, by HORATIO W. DRESSER. G. P. Putnam's Sons, New York, 1900. pp. 255.

This, we understand, is the tenth book of this prolific young mystic. We notice in this no telepathy, theosophy, or mind cure in their familiar forms, but there is a subdominant tone throughout that suggests that the author has long frequented the adyta of adepts in these lines. He believes in his new point of view in educational ideas in equanimity, the subconscious mind, the spiritual ideal, the expression of the spirit, its ministry and that of pain and evil, in organic perfection, philosophical ideals and in immortality, and tells us also with earnestness and with quotations from Emerson, Amiel, Lowell, Froebel, John Fiske, Mr. Salter, Browning, and even Henry Wood, from which points the experienced reader can calculate his orbit although he may not have time to drift with him through all the rather pleasant meanderings of his pages, but a strenuous reader will wish they were better, or if that could not be, that they were worse.

Studies from the Yale Psychological Laboratory. Edited by Edward W. Scripture, 1899. Vol.VII, pp. 108. Yale University, New Haven, Conn., 1900.

This volume contains a major article entitled "Researches in experimental phonetics," and a minor one on "Observations on rhythmic action," both by Dr. Scripture.

Proceedings of the Society for Psychical Research. Oct., 1900. Vol. XV, Part 38.

This number is devoted to the divining rod, with many illustrations and candid presentation of evidence both ways.

Essai sur l'Imagination Créatrice, par TH. RIBOT. F. Alcan, Paris, 1900. pp. 304.

This study is worked out with the author's usual intelligence, lucidity, and sense. The intellectual, emotional, and subconscious faculties of imagination are distinguished from each other as well as from its organic conditions. The development of the imagination in animals, children, primitive man and myths, up to the higher forms of invention, with certain general laws of its development are next described. The following are its principal types—plastic, diffluent, mystic, scientific, practical, mechanical, commercial, and Utopian.

Variétés Philosophiques, par J. P. DURAND (DE GROS). F. Alcan, Paris, 1900. pp. 333.

The traces of metaphysics in natural medical sciences interest this author first. He then discusses the two species of cells in the nervous centers, Taine's ontology, Fourier's psychology, polyzoism, free will, the unconscious, pantheism, creation, finality, and miracles.

L'Imagination et les Mathématiques selon Descartes, par PIERRE BOUTROUX. F. Alcan, Paris, 1900. pp. 45.

We have here a collection of quotations and paraphrases of mathematical authors since Descartes to enforce the precept that the imagination is an essential part of the outfit of a mathematician, both for knowing and for demonstrating in his field.

The Conception of Immortality, by JOSIAH ROYCE. The Ingersoll Lecture, 1899. Houghton, Mifflin and Co., Boston, 1900. pp. 91.

The author sums up his case by conceiving the world as a rational whole, a life in which the divine will is uniquely expressed. Every aspect of this life must, therefore, be unique and mean something that can only get an individual expression. But while we want to love and know there are in our present form of consciousness no true individuals to be found, yet because we are one with God, our lives must in the end attain individual significance, so that we are only hints of individuality not yet revealed. Hence the real individuality, which we mean to express, must have its final conscious utterance in a life that is conscious, and though independent of space and time, is continuous with our present fragmentary, flickering being.

Nietzsche's Ästhetik, von JULIUS ZEITLER. H. Seeman Nachfolger, Lepzig, 1900. pp. 308.

At last we have a good digest of Nietzsche's views in clear language, which ought to be translated, treated under the metaphysics of æsthetics, art psychology or criticism, and physiological æsthetics. The author is intent mainly upon digest and characterization, and both quotation and criticism take a secondary position.

The Individual. A Study of Life and Death, by NATHANIEL S. SHALER. D. Appleton and Co., New York, 1901. pp. 351.

The chapters are—the individual's place in the universe, organic individuals, duration and nature of individuality, place of organic life, growth of sympathy, expression of individuality, appreciation of others, fear and valor, attitude of man and society to death, relation of parent to child, old age and its utilization.

Man and His Ancestor. A Study in Evolution, by CHARLES MORRIS. The Macmillan Co., New York, 1900. pp. 238.

Since Darwin, we are told the subject of man's evolutionary origin cannot be said to have been dealt with for itself alone, but Mr. Morris treats man's ancestry, relics and ancient man, the progress from quadruped to biped, freedom of the arms, development of intelligence and language, how the chasm was bridged, first stage in human evolution, the conflict with nature, warfare and civilization, the evolution of morality, man's relation to the spiritual.

La Respirazione nelle Gallerie e l'Azione dell'Ossido di Carbonio, da ANGELO MOSSO. Tip. Treves, Milano, 1900. pp. 322.

Professor Mosso has brought all the marvellous resources of his genius for apparatus to bear here for studying the action of the lungs in the great railway tunnels in Italy, and describes the pressure, state of the blood. action of the heart, curve of fatigue, etc. The work was undertaken at the suggestion of the Minister of Public Works.

Apes and Monkeys, their Life and Language, by R. L. GARNER. With an Introduction by Edward Everett Hale. Ginn and Co., Boston, 1900. pp. 297.

Last spring Mr. Garner gave the members of the Psychological Seminary at Clark University great pleasure in detailing his acquaintance with monkeys. A sagacious publisher upon hearing him forthwith engaged him to amplify it to a book, which he has here done. Whatever we may think about the soundness of the author's theories or the range of his knowledge, he has certainly here made an interesting and valuable book, which is also gotten up in very presentable style.

An Introduction to the New Testament, by BENJAMIN W. BACON. The Macmillan Co., New York, 1900. pp. 285.

After the usual discussion of the history of New Testament thinking since Strauss and Renan, the author traces the growth of tradition and formation of the canon, and then turns in detail to the Pauline epistles. The third part is devoted to the Catholic epistles, viz., Peter, James, Jude, and 2 Peter; the fourth part to the historical books, synoptic tradition and writers; and the last to John's gospel and the apocalypse.

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A METHOD OF MAPPING RETINAL CIRCULATION BY PROJECTION.[1]

By R. M. OGDEN, B. S.

The object of this investigation was to study the entoptic phenomena of blood movement in the retina, and to obtain maps by an introspective method which should indicate the course of the vessels in as satisfactory a manner as possible. Numerous superficial observations have been made along this line, but reference to physiological and psychological literature failed to bring to light any detailed maps of the blood movement as observed subjectively upon a bright field. Maps in varying degrees of satisfaction have frequently been traced by many of the 'shadow methods,' *i. e.*, by actual projection of the vessels upon a screen. These, however, reproduce only the larger vessels with any degree of definiteness, and do not indicate the direction of the blood flowing through them. This method is here employed only as a means of verifying the other work.

§ 1. HISTORICAL.

The perception of the phenomena of blood movement in the eye seems to have first been described by R. W. Darwin in 1786. Darwin states that he could see these movements when gazing at the sky or some other bright field, after holding his breath and rubbing his eyes. The experiment was thus facilitated by an increase in the amount of blood sent to the eye. He believed the appearances to be dependent on the general state of the observer's health, and to be most distinct after the eye became fatigued.[2]

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[1] From the Psychological Laboratory of Cornell University.
[2] C. J. Burch: The Retinal Circulation, *Nature*, LIII, 558.

In 1819 J. E. Purkinje published his observations,[1] and noted that the retinal circulation might be observed subjectively under certain conditions. By directing the attention on a clear flash of diffused light, he could see bright spots appearing in continuous courses which emerged at irregular intervals at the same points, completed their courses, and disappeared. Purkinje also laid down a method for projecting the vessels as shadows. This he accomplished in a dark room, by directing a strong light on the sclera. When the light was moved slightly from side to side, the vascular shadows became visible in the glare before the eye.

J. Mueller called attention to these blood movements in his Handbuch der Physiologie des Menschen, published in 1840 (II, 390). He indicated that an expression of such movements might be observed by glancing at a bright even-toned field, such as the sky, a patch of snow, or a white paper uniformly illuminated by a steady light. He saw nothing save confused movements, which rushed towards one another and passed one another in irregular smoke-like courses. Mueller considered it impossible to determine the direction of the movement. He accepted it as a manifestation of the retinal circulation. In addition, he noted certain definite phenomena occurring when one stoops and rises again suddenly, which he attributed to congestion caused by the ebb and flow of the blood. These movements were described as a "leaping" of dark bodies in various directions over the field.

O. N. Rood, in an article published in 1860,[2] states that by gazing intently at the bright sky or other illuminated field through three plates of cobalt glass he was able to obtain a view of "small bodies like animalcules" which travelled over the field in all directions. The spots seemed to be yellowish in color, and appeared elongated in the direction of their motion. A convex lens held before the eye did not alter the occurrences, a fact which indicated that these movements were situated in the retina. Near the axis of vision, the moving body seemed always to pursue the same direction, and to disappear at the same point. Rood concluded that these phenomena were probably due to blood corpuscles.

These bodies may also be observed through a certain thickness of a solution of cupro-sulphate of ammonia, though not as perfectly as with the cobalt glass. Through red, orange, yellow, green or purple media they are still less distinct. Rood advanced a theory, in explanation of these appearances, as follows. The blood discs are yellow, and therefore opaque to blue and violet light. They, consequently, cast shadows when such media are interposed. But since the retina is strongly impressed with blue light, the portions protected by the corpuscles experience a complementary sensation, and instead of a dark shadow, a yellowish moving speck results. Since yellow media are transparent to red, orange, yellow and green lights, no very perceptible shadows are cast when these are employed.

In another article,[3] published a few months later, some additional observations were noted, mainly the facts that faint indications of movements may be seen with the naked eye, and, further, that the moving bodies are sprinkled over the field, and do not appear in compact masses. Quoted in Rood's paper are some of the results of W. B. Rogers. Following Darwin and Mueller, in their observation that

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[1] Beobachtungen u. Versuche zur Physiologie d. Sinne, I, Prag, 127.
[2] The American Journal of Science, XXX, 2nd series, 264.
[3] *Ibid.*, 385.

the phenomenon is facilitated by an increase in stimulation of the retinal blood supply, Roger maintains that after continued effort of vision, active exercise, or other stimulation of the circulation, these dots are readily seen in broken curves, which come and go in such a manner as to indicate the presence of certain prescribed and permanent channels. As one continues to fixate a bright field, a shade covers one's vision, and one sees, upon a dark background, innumerable streams of particles which move in loops and curves and retain a constant pattern. These courses have a "tawny yellow tint," and last only one or two seconds. The shade passes, and returns after an interval, though the courses are then less distinct.

Rogers indicates several methods for obtaining this projection:

(1) gazing through a black paper tube at a white surface till the eye is fatigued and greatly excited;

(2) gazing for a few seconds into a pocket microscope held at about focal distance from the eye;

(3) a method previously indicated by Purkinje: the light of a spirit-lamp, with a salted wick which gives an intense yellow flame, is concentrated on the eye by a convex lens of three-inch focus. The bright field thus observed soon resolved itself into a mass of small, round, densely-packed moving bodies which appeared light against a darker ground. They seemed "packed together like a fine mosaic," but their paths could be traced as they moved at a slow uniform rate through the narrow channels. Rogers adds that if yellow plates of glass were interposed the bodies appeared more distinctly. He attributes the indistinct vision, which is concomitant with eye-weariness and faintness, to an increased congestion in the vessels.

Helmholtz in his Optics [1] reviews the subject, and states that Vierordt saw a rushing movement when he agitated his spread fingers before his eyes. This movement was attributed by the observer to retinal circulation. Helmholtz affirms that neither Meissner nor he himself has been able to see such movements; they find only an appearance of "shoreless streams." However, he does not question Vierordt's phenomenon or its explanation. The observations of Purkinje and Mueller are also cited, and, in the light of these, with the directions furnished by Rood, Helmholtz concludes that the phenomenon undoubtedly proceeds from blood movements in the retina. In explanation, he advances the theory that the corpuscles become jammed together in large masses in the smaller vessels, so that the portion of the capillary tube ahead of the check is emptied. At last this blockade is released, and the whole mass moves quickly on. This causes the appearence of definite movement through certain restricted portions of the smaller vessels. Similar phenomena are observed in capillary circulation under the microscope. Helmholtz concludes that the bright spots observed should be considered as the optical expression of "little stoppages" in the retinal blood flow, which occur only in certain narrow passages of roots of vessels.

Landois and Stirling[2] cite Boisser as advancing the theory that the appearances may be caused by the red blood corpuscles in the capillaries. These, acting as small light-collecting discs, concentrate the rays falling on them from without, and throw the light upon the rods of the retina. In order to accomplish this, each corpuscle must be in a special position,—probably with its broad face toward the light. If it rotates, the phenomenon disappears. This theory is interesting, but (as will be shown later) the facts of observation and histology do not substantiate it.

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[1] Handbuch der physiologischen Optik, 2nd ed., 1896, 198.

[2] Manual of Human Physiology, 1895, II, 995.

§ 2. Experimental.

Method. After a careful consideration of the methods indicated in the literature, a simple proceeding was adopted as follows. A rectangular screen, 67x87 cm., of even-surfaced, white, translucent paper was erected in a window facing the western sky, the light from which was unobstructed by trees or other objects. This screen was marked off in squares of 2 cm., and at the center was placed a fixation-point. Before the screen a desk was arranged with drawing-board, on which were placed papers with cross rulings like those on the screen, which brought the eye in a line with, and 92 cm. distant from, the fixation point. An adjustable chair for the observer, blue glasses for media, and shades for the unused eye completed the apparatus. Each observer worked with the right eye, the left being comfortably shaded so as not to interfere with the vision of the other. Observations were made both through the blue glass and with naked vision. The moving points were observed, and their tracks carefully noted by aid of the arrangement of squares, and then transferred to the map.

In attempting to check or verify the results obtained in this way, all the classical methods of shadow-projection were investigated. To enumerate a few:

(1) In a dark room a candle is held near the eye which regards the distance. The vascular courses are supposed to appear as dark lines on a yellowish background. These courses come out distinctly when the candle is moved.[1] This method was tried, but no very satisfactory results were obtained.

(2) The Purkinje method. A strong light is focussed on the sclera at a distance as far as possible from the cornea. When the light is moved slightly from side to side, the courses appear before the eye. This method requires delicate handling, owing to the burn and the general strain caused by the focussing of a strong light upon the eye. No very satisfactory phenomena were observed, and the method was not found to be practical as a means of verification.

(3) W. C. Ayres[2] has enumerated several methods involving modifications of those already described. The most important requires a
room, and an even, constant source of light. This light is
d through the pupil on to the retina by means of such dull re-
as a gold ring or a teaspoon bowl. The shadows are thus pro-
s in the other methods. Ayres can see them very distinctly on
card held a short distance from the eye, and has been able to
p of the macular region which is surprisingly intricate in
regular in contour.

xamination of Ayres' map, however, discloses the fact that
rses were traced with any definiteness. The fine net-work of
s between these is arbitrarily indicated. He is able to note
ughly, but states that he cannot differentiate veins from
ugh at times he perceives some indication of the direction

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dall, in de Schweinitz, Am. Text Book of Diseases of
Nose and Throat, 1889, 140.

f. Augenheilkunde, Wiesbaden, 1884, XIII, 29.

of blood-flow. With this method, as with the method from which it is derived, it is necessary to keep the light on the retina in motion, by a side movement either of the reflector or of the head. This, of course, introduces an error in judgment when one attempts to map the vessels. We attempted to reproduce Ayres' results, with a trained observer, but our success was slight, owing to the great difficulty experienced in directing the proper light upon the retina.

(4) The second Purkinje method has already been outlined as it was worked out by Rogers. We repeated the experiment, and noted the movements described; but they were not nearly so numerous as those obtained by gazing at the bright sky, nor as satisfactory, owing to the very limited field which the lens allows. We also noticed that muscæ volitantes appeared frequently and proved distracting, as it was hard to differentiate them from the vascular courses.

(5) The method adopted is the simplest and for many reasons the best of those which the literature indicates.[1] It consists in glancing through a moving pinhole or steropaic opening toward an evenly illuminated screen. Both openings were employed, but the steropaic has the advantage, since by agitating it in various directions considerable portions of the retinal field are exposed. Vertical movements when the opening is held horizontally bring out the transverse courses; horizontal movements with a vertical opening show the longitudinal vessels. They appear fully as definitely as Ayres' courses. The fovea is not normally projected, nor is there any indication of the direction of the movement; but both these points are satisfactorily given by our working method. It is, accordingly, with this verificatory method that we are concerned, the rest having been discarded as more complex and in general less satisfactory.

It may be of interest to note that an investigation was made into the possibility of obtaining a photograph of the retinal vessels. The literature upon this subject was worked over, and a number of methods studied, but it was found that the experiment is as yet too primitive to furnish any satisfactory record of the smaller vessels or capillaries. Since these are the courses of main importance in the present work, the idea of photographing the retina was abandoned.[2]

§ 3. Introspective Results.

Maps were obtained from four observers in the manner detailed. The general characteristics of their observations were uniform and not greatly at variance with the results obtained

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[1] de Schweinitz, 140.

[2] C. Panel: D'un moyen pratique de photographier le fond de l'oeil. Paris thesis, 1887.

W. Thorner: Ueber d. Photographie d. Augenhintergrundes. Berlin thesis, 1896.

G. Aarland: Internationale medizinische-photographische Monatsschrift. Leipzig. II, 1895, 4.

Ludwig Jankau, in same volume, 18.

A. E. Fick: Bericht ü. d. zwanzigste Versamm. d. ophthalmologischen Gesell. Heidelberg, 1899. XXVII, 197.

Th. Guilloz, in Revue medicale de l'est. Nancy, 1895. XXVII, 212.

by the authorities above quoted. Two of our observers gained their most satisfactory data after interposing a blue glass between the eye and the field of vision. The other two worked for the most part with the naked eye. It was noticed that the dots were less plentiful but slightly more distinct when seen through the blue glass. This may be accounted for by the fact that on the blue field there seems to be a darker ring about the spots, which aids to differentiate them from the background. Retinal rivalry caused by the black screen over the left eye was experienced to some extent by all the observers, but it was quickly overcome, and did not return after the first few sittings.

The more detailed notes made by the observers, whom we shall designate as *B* (Mr. T. Bliss), *W* (Dr. M. F. Washburn), *C* (Miss J. A. Cochran) and *O* (Mr. R. M. Ogden), are as follows.—*B* procured the most elaborate map of all. He is a careful, patient observer, and seemed to obtain, without trouble, definite courses over all parts of the field of vision. The more remote courses were usually longer and perhaps less fine in detail; still they repeated themselves frequently, and seemed to offer little difficulty as to their exact position.

Throughout the field *B* differentiated the appearances into two classes. (1) As to motion: there seemed to be a class of spots (*a*) which moved very rapidly through a considerable distance, and merely indicated their general direction. These were, for the most part, situated beyond the macular region. Their courses appeared as mere curves or straight lines. There was also a class (*b*) of slower moving spots, whose courses were more definite. They traversed shorter distances than the others, and were situated for the most part about the macula. (2) As to color: *B* used the blue glass exclusively, and observed spots both lighter and darker than the background. The lighter spots were the largest and most numerous. In general, they appeared to have dark borders and to be of a faint bluish tinge. The darker spots were smaller, less distinct, and infrequent. *B* has also seen spots which appeared at first as dark shadows. As they approached the center of the field they brightened for a brief interval, then darkened, and finally disappeared as they came.

The phenomena which are supposed to result from fatigue, as described by Rogers, were all carefully noted by *B*. His results demonstrate that such appearances could be seen, but not at all frequently, nor in a very satisfactory manner. By gazing through a black tube at a bright field he noted one course like a white line. This may have been a particle in the humor, since such bodies not infrequently appear as white, thread-like lines. Courses of the same type, together with a general movement over the field like a gentle ripple of water, were seen when glancing through a lens held against the sky. Two courses thus picked out were checked on the other map. Similar projections were obtained by squinting the eye and glancing toward the screen without the mediation of tube or lens. These may also have been caused by muscæ volitantes, or by shadows cast by the eye lids or eye lashes.

W worked exclusively with the naked eye. Through all her experimentation she has been unable to procure very satisfactory courses in the right portion of the visual field. She obtains a number of well-defined paths, which constantly repeat themselves, in the region roughly indicated as from 8 to 18 cm. to the left of the fixation point upon the projection screen. These are so far removed from the center

that it is impossible to check them by shadowing the vessels themselves. Several expedients, such as cutting off the light from the left portion of the field, were resorted to, in the hope of forcing the attention on the right half; but they proved of no avail except, perhaps, to bring out the macular capillaries somewhat more clearly. By stimulating the left eye, in which *W* could see movements on the right or nasal side, and then changing to the right organ, we were able to bring out a few slight movements in the smaller vessels to the right of the fixation point. At last, by the use of a stationary pinhole through which the screen was fixated, a few satisfactory tracks about the center were procured. This restriction in the phenomena of circulation in *W*'s eye can be attributed only to a persistent habit of attention which seemingly cannot be overcome. The courses to the left of the field run through considerable distances, but are not noted with any of the fine detail which the vessels themselves are known to possess. Yet the general direction of the flow is definitely mapped, and, by reason of numerous repetitions of the same movement, we must accept the tracks as fairly accurate.

The nature of the spots themselves was usually lost in the observation of their movement. At times, however, elliptical or circular spots were described, which were generally lighter than the surrounding field, and possessed an irregular, dark border. The paths near the macula were more definite and perhaps more rapid than the others.

C's results were greatly handicapped by a fatigue which always set in early in the test, and put an end to reliable tracing. This fatigue caused the appearances to be blotted out entirely, and was accompanied by a distinct loss in power of concentration. The increase in the stimulation of the retinal flow, which has been noted as attendant on fatigue of the organ, was thus discounted and rendered useless. *C*'s best results were obtained with blue media. In regard to the character of the dots, she made the same general differentiation as *B*, viz.: that small, slow-moving dots operate near the macula, while larger, clearer specks move in a rapid, jerky manner through the remoter parts of the field. The tracks mapped about the fixation-point were frequently repeated, and in many cases checked with the actual vascular projection. Those further out in the field were for the most part indefinite.

O gained his most definite results in the macular region. There were times when movements in the periphery were noted, but they were not reproducible except as to general direction. Fatigue usually occurred after from 15 to 20 minutes' observation, and was accompanied by diminution of attention which rendered further experiment difficult. Many more courses were seen without the blue glass than with it, but they were not so distinct. *O*'s best results were obtained by a successive use of the two methods. In general, the spots were brighter than the background, though occasionally vague, moving shadows were perceived. Movements were commonly more rapid in the periphery. Courses varied in length from mere flashes to clearly defined tracings. The spots were devoid of color, save when the blue glass tinged them with its hue. On a bright day the spots sometimes had dark centers, and darker borders surrounding a light ring. The shape was not definitely noted, but seemed to be regular in contour.

O reported the following interesting phenomenon. "One day, when I was removing a dark screen before the window, I glanced at the field, and saw it filled with round, intensely bright spots, distinctly larger than usual. They darted about at a very rapid rate. This only continued for a moment, and, as the eyes became adapted to the light, the spots dissolved into the type of spots normally observed." It

seems possible that this occurrence was due to the suddenly increased stimulation of the retina when the pupil was much dilated.

§ 4. Conclusion.

This study has demonstrated that with a fair amount of patience and attention one may secure a satisfactory map of the movements of the blood through a considerable area about the region of the *macula lutea*. Patience and attention are essential, in view of the numerous objective sources of error. It is very difficult to maintain a fixation-point. When the eye slips away, the courses are materially displaced upon the projection plane. This is particularly noticeable with the method for projecting the shadows of the vessels, in which the observer views the field by intermittent light.

Any increase in the stimulation of the blood supply should produce a corresponding increase in these manifestations, as has been noted by many writers. But for definite and careful observation such increased stimulation is usually of no avail, since under the conditions the attention is at a very low ebb.

The physical basis for these movements is undoubtedly to be found in some peculiarity in the behavior of the blood corpuscles. The Rood theory, before mentioned, is based upon the supposed yellow coloration of the spots. *Not one of our observers could detect any yellowness.* This fact seems sufficient to render the theory untenable.

The Boisser theory has certain attractive features. Its assumption of the action of single corpuscles in focussing light upon the retinal rods will account satisfactorily for those isolated, sudden flashes of brightness which most of our observers reported. On the other hand, certain histological facts speak against this theory. The red blood corpuscles are bi-concave, and differ very slightly in density from the lymph which surrounds them. They are, therefore, calculated to disperse rather than to collect rays of light, if they have any refractile power at all.

The Helmholtz theory treats the phenomenon as the "visual expression of little stoppages" in the capillaries, which cause
emptying in that small portion of the vessel which imme-
ely precedes the obstruction. These brief interstices con-
t the light to the rods, and, by contrast with the surround-
ield, produce the phenomena of bright dots. Histology
strates that brief checks in the blood-flow occur at times
ay be caused in either of the following ways: (1) the
cles jam into, and pile up in, certain narrow vessels; (2)
cles often catch for an instant at the point where a ves-
ches, and so produce a momentary stoppage. Helm-
tributes the observed movements to the first of these

causes, and notes that the phenomena occur only in "certain narrow passages of roots of vessels." Our method, however, has clearly demonstrated that the majority of movements observed take place in vessels of an appreciable size, since they can be readily 'shadowed.' It furthermore seems difficult to believe that an empty space could precede a mass of corpuscles through such long distances as are frequently noted. The mass, when released, should spurt on, quickly filling the near intervening spaces.

It seems more plausible to connect these 'stoppages' with certain brief, jerky flashes which are noted through the field of vision, and to attribute the more prominent phenomena to chance spaces between corpuscles or bundles of corpuscles in the normal flux. The latter appearances may be in some manner aided by a varying refractile power of different portions of the vascular walls. We cannot note this as a fact, but the consensus of opinion among our observers favors the idea that the dots continually repeat themselves through the same portion of a vessel.

The fact of movement is noted before the shape or form of the moving body is perceived. But a careful introspection demonstrates conclusively that the definite, more numerous bodies always appear brighter than the surrounding field, and are regular in contour. We are thus limited to Boisser and Helmholtz for our explanation; but, as has been shown, the two theories admit of considerable criticism. After eliminating all errors, the Helmholtzian notion is perhaps most easily modified into a form which will comprehend our results. The spots are bright; they must, therefore, be conditioned by the passage before the retinal elements of media which readily transmit light. We know that spaces occur between bundles of corpuscles. When the external light pierces such an interstice, the rods behind it will be subjectod to an increased stimulation throughout the distance through which such a space retains its character. This little flash of brightness is then projected in a more or less circular form, and, by contrast with the surrounding field, appears as a light moving dot.

The darker rings and centers, following shadows, and gray appearances in general, may all be attributed to the brief, vague shadows of the corpuscles themselves, when they are collected in considerable numbers. They usually precede or follow the bright inter-spaces.

The rate of movement appears to be determined for the most part by the character of the vessel. Brief stoppages in the flow may offer some slight differentiation from the normal motions. Nearly all our observers note short, jerky movements which might be attributed to such checks in the flow. Yet, as a rule,

the rate of movement is so irregular that we cannot state with exactness when the phenomena should be attributed to a check in the flow, and when to a mere separation of bodies in their course.

Peripheral motion has been judged by one of our observers as faster, by another as slower, than central. The macular vessels are smaller than those in the periphery; therefore the flow would move most slowly in the macular region. But it is difficult to note the details of a movement which takes place in indirect vision. For this reason the courses in the borders of the screen are reported merely as movements in a certain direction, whereas the nature of the paths which are projected near the fixation-point can be reported with great detail.

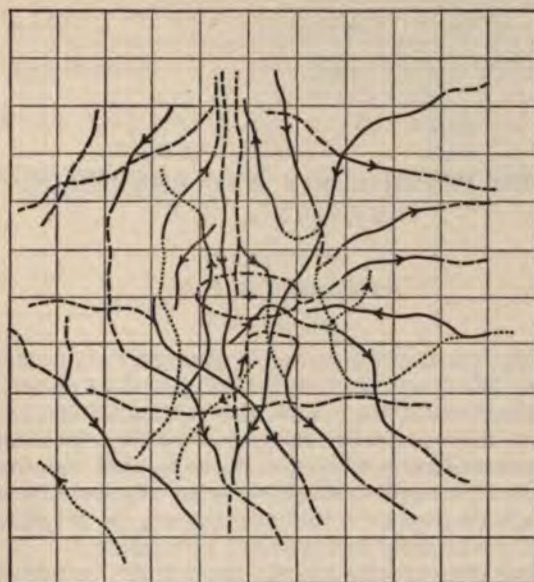
The Maps.

Continuous black lines represent courses obtained by the appearance of moving bodies upon the screen, and checked by the projection of shadow courses in the same position.

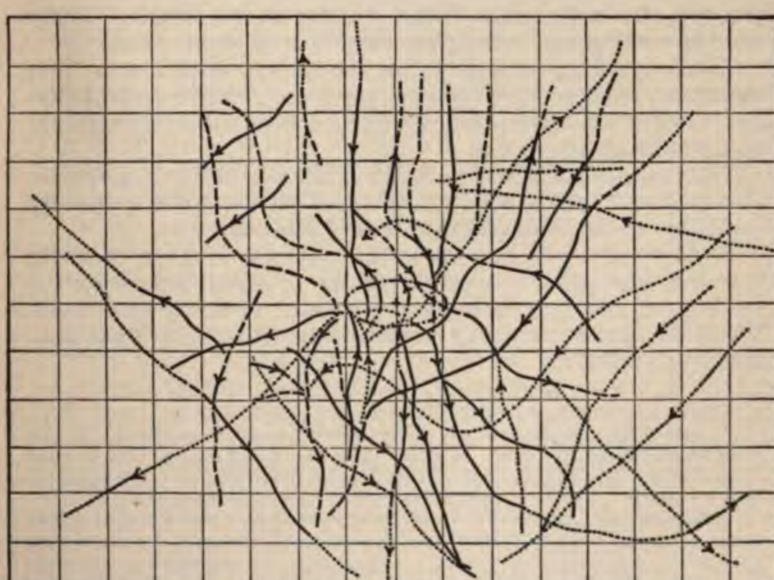
Dotted lines represent courses obtained in the same manner and many times repeated, but not verified by the shadow projections. This indicates in general that they are very fine vessels which have been overlooked or are too small to appear projected as shadows.

Broken lines represent definite courses which appeared with use of the moving pin-hole or slit opening, but through which no movements have been observed.

The elliptical figure about the fixation-point represents the macula lutea.



Map 1. Observer O.



Map 2. Observer B.

ON THE PSYCHOLOGY AND PHYSIOLOGY OF READING. II.[1]

By Edmund B. Huey.

In reading, then, at the ordinary distance,[2] say twelve to sixteen inches, the eye gets its data by a process of photographing successive sections of each line, the photographs overlapping constantly, and being taken at quite irregular distances. The conditions determining the points to be fixated have not been worked out. Introspection gives some suggestions about it which would be easy to write here, but which I believe to be entirely untrustworthy and perhaps misleading.

In reading lines of this length, from three to six fixations are made, usually four or five. But one line is read at a time.[3] In my experiments, about 80% of the line was traversed by the eye, the indentation being greater at the right. There were few retraceals, averaging about one in seven lines.

The forward movements seemed to occupy a little over 40σ, somewhat irrespective of the arc traversed, within certain limits. The return sweep was usually without interruption, and occupied from 50σ to 60σ.

The pauses occupied a variable time, averaging somewhere about 190σ. In fast reading the speed seemed to be gained by lessening the number and duration of the pauses.

It may be interesting to note the average number of words read per fixation. I append results of some representative readings of passages containing from nine to thirty lines each. The data were obtained by experiments with the direct attachment apparatus.

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[1] Continuation of paper published in this *Journal*, July, 1900.

[2] It seems surprising that no study should have been made of the optimum reading distance. Writers here and there advise this or that distance, but the advice seems to rest upon tradition, or upon observation of normal practice, rather than upon any experimental study.

[3] This has been so in every case, I think, which I have tested. The subjects were usually directed to "read for the thought by their own method." Of course, there is a "skipping and skimming" process with which we should all be familiar, in which both lines and thoughts are omitted.

ARTICLE.	LINE-LENGTH.	DISTANCE.	WORDS PER FIXATION.
Cosmopolitan Magazine,	121 mm.	33 cm.	1.83
"	121 "	33 "	1.50
American Journal (10 pt.),	98 "	35.5 "	1.96
" (8 pt.),	98 "	35.5 "	1.91
" (10 pt.),	98 "	33.0 "	1.70
Cosmopolitan Magazine,	60.5 "	33 "	3.63
"	43 "	33 "	2.60
"	37 "	33 "	2.44
"	30 "	35.5 "	1.94
"	25 "	33 "	1.58
"	25 "	33 "	2.16
"	21 "	33 "	2.17
"	21 "	35.5 "	3.33

It will be seen that with the short lines more words are read per fixation, though there is much variation, and little regularity of correlation shown between line length and words per fixation. Such variability is to be expected with the very short line lengths, when we consider how unusual they are, and how apt the eye would be to revert to old habits of moving a certain number of times each second, or for each phrase, or couple of words. In the shorter line-length, many of the movements were evidently from habit and not from necessity; as, *e. g.*, the eye would remain fixated while three or four lines were read, then shift a little and repeat, then zigzag, irregularly perhaps, For the reading of one of the 21 mm. passages above, I entered the following note: "In only three cases is a back and forward movement noticeable. Thirteen appreciably different fixations occurred. One fixation lasted two and one-half seconds, while the reading of whole passage (21 lines) occupied but about six seconds." With lines 25 mm. long, several lines would be read without shifting the eye. Toward the last of a 30 mm. passage the side to side movement was almost nil.

In all cases, with whatever line length, the eye moves oftener than would be necessary to get the printed matter within the range of clear vision. Thus, in my exposure experiments to determine extent of reading field, I read correctly, at first exposure of 15σ duration, one-third of such lines as these of this *Journal* article, on an average of several hundred trials; and this without help of context. Very nearly the half of such lines was read (seen clearly, as guessing was not allowed) from time to time, often enough to make me certain that my eye was capable of dealing with that extent of printed matter, when conditions of printing, arrangement of subject-matter, etc., were favorable. But with this possibility of three and a third to five words of average length per fixation, I actually read, as shown in the tests, about 1.9[1] words per fixation, photo-

[1] The average would be a little more than two words per fixation, if retraceals, breaks in return movement, etc., were excluded, as would

graphing the line at four or five points, even six sometimes. The reason for this can be discussed best when we know just what points are fixated and what effects various arrangements of printed matter may have upon the size of fixation sections.

Rate of Reading.

The reading rate varies greatly with the individual and with the subject matter. G. J. Romanes[1] found readers who read four times as fast as others of apparently equal intelligence and culture. Dr. Quantz[2] studied the matter extensively. He found as great individual differences as are given by Romanes, and states that the fast readers retain more of what they read than the slow ones.

I reget very much that Dr. Quantz has not carefully stated his method of determining the rate of reading. The rate is peculiarly apt to be affected by the conditions under which the test is made. Subjects mean such different things by "reading" a passage. I believe they usually have a tolerably constant rate for a given class of matter, about which they fluctuate according to circumstances. But it is difficult for either reader or experimenter to know whether this standard is being used in any given test. Again, it has not been shown that the fast readers for one class of matter may not be the slow readers for another. The possible speed always, and the actual speed in my own case at least, varies very much with the reader's apperception for the subject matter read.

The studies made thus far on the rate of reading, so far as I have been able to discover, give us no assurance that these sources of error have been eliminated; and knowing the difficulty of making the tests, especially with untrained subjects who so readily misconceive directions given them, I am convinced that we yet need (1) a thorough study of individual differences in rate based upon a *number* of tests taken at different times upon the same kind of reading matter, and repeated for diverse kinds of reading-matter; taking into account the ubject's apperceptive relation to each class of matter; (2) a ll and careful statement of the methods used in determin- rate, if the results are to have anything of final scientific

rranged a series of experiments, having for one of its ob- o throw some light upon the matter of rate in reading,

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for this comparison. Besides, the sections are irregular in often three or four words, at least, are actually read at one

'tal Evolution in Animals," p. 136.
›logical Review, 1898.

and the possibility of increasing it; mainly hoping, however, to get insight into the subject's methods of reading, through the opportunities for direct observation and questioning which the experiments would afford. I do not offer the results as final determinations of rate for these subjects, though for the (uniform) class of matter used, I believe, they are of comparable validity with the results of rate-tests usually made thus far.

Eleven pages, each containing 405 words, were selected from an interesting novel which presented no peculiar difficulties to the reader; the pages having a somewhat similar arrangement of paragraphs, and being of as nearly equal interest and difficulty as possible.

These eleven printed pages were read by each subject, a page at one reading, the time being taken with a stop-watch. The reading was done at one sitting, in a quiet room, free from distraction, with the subject comfortable.

The first page was read silently, at normal speed and by the subject's "usual method," "the way you like to read"—the only other instruction being, substantially, that he read "continuously and for the thought." The second page was read exactly as the first. For the third page the subject was directed to think the words over in terms of sound, to auditize it, but at normal speed, and for the thought. The fourth page was motorized, at normal speed, but without lip-movement. The fifth was as the fourth, but *with* lip-movement. The sixth page was read aloud at the subject's most natural rate. The seventh, eighth, ninth, tenth and eleventh pages were duplications of the preceding as to method (except that but one page was read by "silent normal" method), but were read at maximum speed. In the readings aloud, the subjects were required to read loudly enough to be understood at a distance of fifteen feet at least.

The subjects were given preliminary practice for each page, and were not allowed to read until they understood clearly what was required. In all the readings, and especially in the "silent normal" readings, the greatest care was taken to have the subject fall into the mood in which he would do such readings in an easy-chair at home; and I believe that the results approximate somewhat nearly, at least, what would be obtained under such circumstances.

Below are the results for the twenty university students tested:

The table gives opportunity for various comparisons which may be of suggestive value to those who may work further upon these problems. It will be noticed that the individual differences found for "Silent, own method" reading are found to hold in lesser measure for readings by other methods, for

readings at maximum rate, and in the averages at the right from readings by all methods.

	Subject.	Silent Own Method	Silent Own Method	Auditory	Motor. Lips Closed	Motor. Lip Movement	Aloud	Average
R	Normal Rate	8.8	10.8	10.5	10.9	9.8	4.4	9.20
	Max. Rate	13.5	—	10.8	12.0	8.7	6.4	10.28
B	Normal Rate	7.3	8.4	6.7	6.6	6.7	4.2	6.65
	Max. Rate	8.8	—	7.7	7.3	7.4	5.1	7.26
A	Normal Rate	7.0	7.7	7.0	5.4	4.1	3.8	5.83
	Max. Rate	10.7	—	10.6	9.5	6.7	5.5	8.60
M	Normal Rate	6.7	6.3	4.5	5.5	5.4	3.7	5.35
	Max. Rate	9.3.	—	5.9	7.5	5.9	4.9	6.70
Q	Normal Rate	6.7	6.1	4.9	5.5	5.7	3.5	5.40
	Max. Rate	9.2	—	6.1	6.1	6.0	3.9	6.26
N	Normal Rate	6.6	7.3	7.9	7.9	6.6	4.7	6.83
	Max. Rate	8.8	—	9.6	10.6	8.7	5.5	8.64
E	Normal Rate	6.6	6.7	6.0	5.1	5.3	4.6	5.72
	Max. Rate	8.1	—	5.3	6.4	5.6	4.9	6.06
L	Normal Rate	6.1	6.9	5.1	6.7	5.3	3.5	5.60
	Max. Rate	12.4	—	7.7	7.3	4.8	5.1	7.46
C	Normal Rate	6.0	6.3	5.4	5.1	5.0	3.3	5.18
	Max. Rate	8.0	—	8.2	7.7	6.3	4.9	7.02
G	Normal Rate	5.5	5.6	4.9	4.4	4.6	3.7	4.78
	Max. Rate	7.0	—	5.6	7.2	6.0	4.7	6.10
S	Normal Rate	5.3	5.1	4.6	4.5	4.4	3.1	4.50
	Max. Rate	12.4	—	6.0	6.1	5.5	3.3	5.55
O	Normal Rate	5.0	6.3	5.0	5.0	4.2	3.8	4.88
	Max. Rate	7.1	—	6.3	6.4	6.0	5.5	6.26
H	Normal Rate	4.5	5.7	5.5	5.7	5.1	3.7	5.03
	Max. Rate	7.6	—	6.2	7.1	5.8	5.4	6.36
D	Normal Rate	4.1	4.7	4.1	4.2	4.3	3.0	4.07
	Max. Rate	6.5	—	5.3	6.3	5.4	4.2	5.54
J	Normal Rate	4.0	4.6	3.9	5.0	4.3	3.5	4.22
	Max. Rate	6.2	—	5.2	5.0	5.1	4.6	5.22
F	Normal Rate	3.9	4.7	3.8	4.6	4.4	3.2	4.10
	Max. Rate	5.9	—	5.4	5.6	4.7	3.2	4.96
T	Normal Rate	4.0	3.9	3.7	4.0	3.7	3.6	3.82
	Max. Rate	5.9	—	5.5	6.0	5.2	4.3	5.38
P	Normal Rate	3.5	5.4	4.4	4.5	3.5	3.4	4.12
	Max. Rate	9.7	—	5.6	5.6	4.8	3.9	5.92
K	Normal Rate	3.1	3.3	2.3	2.7	2.7	2.2	2.72
	Max. Rate	3.6	—	3.1	3.7	3.2	3.4	3.40
I	Normal Rate	2.4	2.5	2.1	2.5	2.6	2.2	2.38
	Max. Rate	3.5	—	3.0	3.6	3.3	2.9	3.26
Av.	Normal Rate.	5.35	5.91	5.12	5.29	4.88	3.55	
	M. V.	25.7%	23.1%	25.8%	22.5%	22.4%	13.1%	
	Max. Rate.	8.21	—	6.45	6.85	5.75	4.58	
	M. V.	25.5%	—	24.6%	21.2%	17.3%	16.5%	

NOTE.—The reader having slowest normal rate above had a segmental affection of the retina, which doubtless affected his speed.

The next slowest was a Japanese student who, however, had studied in American schools for a number of years. The numbers represent words read per second.

Throughout the experiments I was most interested in getting insight into the reader's method of reading. Lip-movement was usual with but two or three. One of these was one of my fastest readers, though for those unaccustomed to the method, the lip-movement evidently hindered speed.

By far the largest number seemed to be of the audito-motor type, emphasizing in various degrees the auditory or the motor elements. Readers often indicated their usual method clearly by the ease with which they comprehended and used it when assigned, and by again and again reading pages by the assigned method in almost the exact times used for the "own method" pages.

A strong rhythmic tendency was observed, and this aspect of reading merits a careful study. Readers fall into a natural rate, which gives almost exactly the same times for page after page. (I from time to time tested readers upon several additional pages, by the various methods, and especially by their accustomed method.) Habits of eye movement would seem to be an important factor in setting this pace. For example, the second page readings in the above table were from a page containing fewer lines than the first, though the lines were of equal length, and the only difference apparent was in the inter-spaces between words. The average times for reading the two pages were almost exactly proportional to the number of lines in each, for a somewhat larger number of subjects than are given in above table. I find by experimenting upon lines marked here and there by crosses for fixation without reading, that the eye readily falls into a very uniform rate of progress corresponding more or less closely to its usual rate in reading.

I was constantly impressed with the fact that reading may go on in motor images without any apparent traces of movement of lips or tongue. The movement seemed "up in the head" to many of the subjects.

The fact that we constantly hear our own utterances, has, acting with other factors, indissolubly welded together the auditory and motor elements. I am satisfied that these elements are never quite dissociated in normal reading; and that what subjects call auditizing, or motorizing, is a combination of the two, usually in more nearly equal proportions than their early introspective accounts would indicate.

A purely visual reader is certainly not an impossibility, theoretically at least. The direct linking of visual form to ideas, cutting out of circuit the somewhat cumbrous and doubtless fatiguing audito-motorizing mechanism, would seem to be a consummation to be wished for, from some points of view. When the proper preliminary investigation of the reading-process has been made, this will be one of the most important sub-

jects of pedagogical consideration. Practically, however, I have not found the purely visual type.

Perception of Reading-units.

My various experiments in the exposure of reading matter had for one of their main objects to give suggestions for a rational point of view from which to regard the whole matter of perception of reading-units. I am satisfied that such direct and continued contact with the processes as they go on under conditions which can be controlled is the best road to right theory in this difficult field.

I offer a tentative view of the matter, which may be generalized all too soon as I well know; but which, I am convinced, shows leadings toward the truth that will appear upon fuller investigation and more mature reflection.[1] Much is to be gained by regarding the perceiving of letters, words, and phrases as phenomena of association. When a letter or word is seen, the most habitual associate tends to appear in consciousness, in preference to less habitual ones; and the habitual associate will come so quickly as to fuse with the first if the association has been inveterate enough. Every letter, combination of letters, syllable, combination of syllables, word, combination of words, phrase, etc., has associates more or less habitual. Not only does the perception of the letter or word arouse the idea of its absent associated letter, word, etc., but, when the printed associate follows, its perception is facilitated in proportion to the extent of the habituation.

The child learns to read, either by associating the visual forms of letters with their names or with their sounds, or (in the word method) by associating the visual forms of word-

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[1] My study of reading was interrupted in the spring of 1899, while yet in the observation stage, as I had first planned that it should extend over another year. I made a temporary summing up of the study at that time, but refrained from publishing in the hope that my prospective teaching duties would not prevent my making a more satisfactory conclusion of the study, or, at least, would permit my making a better and fuller presentation from the considerable amount of data already on hand.

I have not since found time or strength for further experimentation or reflection upon the subject; and regretfully publish it mainly as it stood in the earlier form.

Among the later and valuable literature which has appeared, the article by Bryan and Harter on "The Telegraphic Language" (Psych. Review, July, 1899), has been of especial interest to me. Starting from a quite different point of departure, the authors, it seems to me, reach much the same general conclusions as to the perception of reading-units as those to which I have been led in my study of the reading process. It has, of course, been encouraging to find this at least partial corroboration of my theory in the work of other and experienced investigators.

wholes with word-sounds and meanings. The association between the optical form of the letter and its *name* is not strengthened by later reading, and disappears, comparatively, in favor of the association with the letter's *sound*. This is clearly shown in my earlier experiments,[1] and in the still earlier ones of Prof. Cattell, in which the naming of isolated letters required more time than the speaking of short words.

Whether or not the association of the letter's visual appearance with its sound is arbitrarily memorized by the child in learning to read, it comes just as truly and certainly as he practices reading. A pupil taught to read by the word method first associates the optical form of the word as a whole with the sound of the word without linking parts of this sound with particular parts of the optical form, *i. e.*, with letters; and so his reading may go on for awhile. But gradually, even if he has never been taught that the optical form is composed of letter units, he will note the likeness of the crooked beginning of "star" with the crooked beginning of "slipper," *e. g.*, and will form an association of this crookedness with the hissing sound noticed as occurring in both words. The association of the optical form of the letter with its sound thus arises and soon becomes inveterate. Doubtless the appearance of letters at the beginning and end of words facilitates the linking of particular sounds with particular letter-forms; but it would come in any case; and I think it tolerably certain that, whatever the learning-method, the reader must and does come to feel the force, visual and auditory, of individual letters before he reads with much facility.

Now this optical crookedness and this hissing sound are comparatively seldom found alone, and occurring as they do with other optical shapes and other sounds tend to call up these other shapes and sounds when presented, and call up preferably and most quickly those with which they have been most often associated, other things being equal. If the visual "a" has most often had "x" appearing at its right, the sight of "a" will, other things being equal, tend to arouse the visual representation of "x," and the *sound* of "a" aroused by association with its optical form will tend to arouse the sound of "x" preferably. Of course the optical form and the sound "a" have been associated with many other letters, and the associative tracts representing these will also be aroused more or less. The associative tracts representing "z" and "q," letters seldom given with "a," will scarcely be aroused at all. Now if the word "ax" is suddenly exposed or appears in reading, the sounds corresponding to "a" and

[1] *American Journal of Psychology*, July, 1898.

"x" will at once come up as the most inveterate associates with these optical forms. But the optical form "a" will call up also its preferred associate "x;" and the sound of "a" will do the same for the sound of "x;" with a strengthening of the optical and auditory "a" by "x" also in proportion as "a" has more or less often preceded it as compared with a probably preferred "e" (in suffixes, etc.). Perhaps the association of optical forms from right to left may be as facile as that from left to right if we accept the apparent fact that the eye receives no data during its movement forward.

In a longer word such as slipper, "s" may subarouse the forms and sounds of various other letters than "l," though the association to "l" is facile as compared, for example, with that to "x." "l" has more or less frequently been associated with "i" following, and tends somewhat of itself to call it up as compared for instance with calling up "x." But the combination "sl" has far more frequently been given with "i" than has "l" when "l" has stood alone, and thus the effect of "s" preceding "l" is much to facilitate arousal of tracts representing "i." The combination "sli" tends to arouse comparatively few letters, such as "p." "t," "c," "m," "d," etc., and the trend of association is more and more constrained as less of the word remains.[1] The combination "nigh," for example, would almost invariably arouse "t," its almost invariable associate. In general, it only requires a direct application of fundamental principles of association to justify the statement, confirmed, however, by its agreement with the facts of observation, that letters have more or less preferred associates according to their habitual arrangements into words in a given language; and that letters presented in these preferred sequences mutually strengthen the visual and auditory perceptions of each other, and thus arouse the apperceptive complex representing the visual form of the word and its sound. When letters in nonsense arrangement are exposed, subjects often state that they have clearly seen many more than they can repeat to the experimenter. The letters as optical forms tended to call up their preferred letter-associates, but these rather hindered than helped the perception of the adjoining letters, l there could be no apperceptive knitting together into a nlex which could be remembered.

e perceptions of the various parts of a letter shoot to-r into the perception of the whole letter, the part percepmutually assisting each other according as, from being resented together, they have habits of interassociation; iitting together into the complex perception-whole "a,"

James's Psychology, Vol. I, p. 365, *et al.*

"x," or what not. This first fusion seems to occur below the threshold of what we ordinarily term consciousness. The visual perception of the letter-unit is instantly supplemented by more or less of audito-motorization of its sound.[1] The perception of a word occurs similarly except that here auditory and motor (tactual), as well as visual elements enter into the fusion, in various proportions as the reader tends to the visual, auditory or motor type. The letter perception-units shoot together again in the perception of the whole word, the letter-perceptions mutually assisting or hindering each other according as the printed arrangement follows or violates habits of interassociation. There is the direct fusion of the *visual* letter perception-units; and the indirect but similar fusion of the auditory and motor elements that are linked with these visual units. This fusion into a word-unit is probably below the threshold of consciousness, for the most part, in most reading.

Word-perception is facilitated or hindered, it is true, by other factors than past co-presentation in vision, hearing, or speech. Certain auditory or motor elements blend easily with certain others, and the perception of these harmonious combinations will, of course, be comparatively facile though the combinations be new. The intrinsic difficulty of other combinations may overcome the tendency to facile perception incident to habitual interassociation. There are other factors which would have to be taken into account in an exhaustive treatment.

Now the knitting together into letter-wholes of data given from printed letter-parts seems to begin the instant the parts are presented, quite automatically, and may occur simultaneously at all points throughout as much as half the present *Journal* line-length, as it seemed in some of my experiments on extent of reading field. Subjects would state that they saw the letters clearly as letters; though they could not be remembered long enough for reproduction unless their transient life was reinforced by union into the more stable and permanent word-unit; and still better if this word-unit could be reinforced by union into some characteristic word-group; the higher complex units saving all their elements from falling into speedy oblivion.

Exactly similar are the readers' habits of association from word to word, and from phrase to phrase. The exposure of the word "A" beginning a sentence subarouses many of its past associates, preferably substantives or descriptive adjec-

[1] I allow myself here to use the term perception for processes which are ordinarily unconscious or subconscious. Perhaps, however, my meaning is as evident as I could make it with a more accurate use of terms.

tives. If "large" appears after it, the possibilities as to what may be the third word are narrowed to a manageable list, which are perhaps all subaroused. If "juicy" follows, the associations for the fourth word are still more limited, and often one or more of these is made so much more probable by the context or particular situation that the reader's apperception scarcely needs the appearance of the word "apple" to complete the phrase. On the other hand we can easily understand that the appearance on the page of a word violating this order of expectation would have its recognition hindered rather than helped by the existence of this apperceptive expectancy; and we are thus prepared to understand why the reading of nonsense matter takes about twice as much time as that of sense passages.

I shall defer further discussion of the perception of word-groups until I have given account of some experiments which I have made upon the associative and interpretative processes in reading.

Interpretative Processes in Reading.

Of the interpretative processes in reading there would seem to have been little experimental study thus far. The subject seems difficult to approach, yet of the greatest importance and interest. I arranged the following tentative experiments in the hope that, whatever the direct results, they might suggest a helpful method for further investigation.

Two passages of at least average interest and of only moderate difficulty were selected, one a description taken from a magazine article of how a spider spins its web, the other from the introduction to Percy's Reliques, describing the arrangement for the entertainment of Queen Elizabeth at Killingworth Castle. The passages contained some seventy-five words each. These were typewritten, and the lines cut out and pasted end to end on strips of cardboard, so as to make sense continuously throughout in a single long line.

From other typewritten copies the single words were cut d pasted on small pieces of cardboard. These cards were n shuffled, and were exposed, by means of a krypteon,[1] to subject, one word at a time, in haphazard manner. Before exposure, a ready signal was given, and the exposure l four seconds. The subject was seated comfortably in a . room, and was directed to look at the exposed word, and associations to play as they would in any direction.

exposure of the sense matter was under similar general ons. The first word of the passage was exposed, then

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[1] ribed on page 403, Sanford's Experimental Psychology.

the first two, then the first three, etc., a new word being given at each exposure along with the preceding context, the subject attending mainly to the new word in each case. In a few cases two or three words forming a phrase were exposed together in the sense passages, but usually but one new word was exposed.

Another sense passage of 130 words from a rather interesting magazine article on "Tribal Religions" was exposed, in phrases of two to five words, from beginning to end continuously, with context always in sight. To illustrate the character of the division into phrases, the following are some representative ones: "Political party," "Among their own countrymen," "Of the Pharisees," "Declared that," "It is true," etc.

Three subjects have been tested on the first series. The passage exposed by phrases has been given to one subject only. About a month was allowed to elapse between the exposure of the isolated words and of the context passages, which they formed.

The results show characteristic differences between the associations from isolated words and from words given in context for all subjects, though in most respects the subjects have very considerable individual differences.

The words given in isolation gave a much greater variety of association than did the context words, though the total amount of associated contents suggested by them is considerably less. When the isolated word appeared there was usually an indefinable recognition of the visual form of the word as familiar; and accompanying or very closely following this (probably the latter, though the subjects are not explicit), the word is usually "mentally pronounced." One subject whom I shall designate as "A" practically always had this mental pronunciation; another to be designated as "B" had it almost always, often with some associated word as "Atlantic cable," when "cable" was exposed, or "Can-can," when "can" was exposed. The third subject to be known as "C" quite frequently mentioned that the word was motorized, when first exposed, but more frequently did not mention this. This subject showed much more tendency to think in visual terms than did the others. The motorization of a word would seem to have often been present and disregarded, as was discovered sometimes by questioning. Usually, however, the subjects were not questioned at all, but dictated as fully and accurately as they could just what had been in consciousness during the four seconds, doing this immediately after the end of the exposure; the experimenter recording their account as nearly in their own words as practicable consistently with the necessary condensa-

tion. It may be mentioned that the subjects were all university men and accustomed to introspection. This subject "C" very frequently had associated phrases come up a little *after* the beginning of the exposure, and these were almost always mentally pronounced.

The subjects were generally unable to say after careful introspection whether this mental pronunciation meant motorizing, or auditizing, or a combination of the two. They inclined in general toward the latter view, emphasizing the motor or auditory elements according to circumstances.

After the visual recognition and mental pronunciation of the isolated word was apt to come a mental pronunciation of some phrase or other word in which it had often occurred to the subject: as "Sweet by-and-by" from "by," "Himself, herself, itself," from "himself," "Vertical writing" from "vertical." The word was rather especially apt to suggest some line of poetry which would often be but dimly suggested, leaving the subject with a vague and tantalizing feeling of something which he could not get. This occurred much more often with subject "B" than with the others. The vivid arousal of the *feelings* belonging to words and phrases which were thus but subconsciously aroused was a phenomenon often occurring with him. In general, words showed a tendency to call up groups with which they had been rhythmically connected. Words were often pronounced "interesting," "agreeable," "full of meaning," or the opposite of these, and occasionally these judgments seemed to refer to the sound or visual appearance of the words themselves; but more usually the feeling seemed to be traceable to some particular associations or uses of the word in past experience; and though this reference could not always be made, as was the case also with the suggested phrases from poetry, still it seems probable that the feelings were usually associatively mediated by words or situations which do not any longer appear above the threshold.

As has been said the associations from isolated words were of the most varied character. The word, "top," for instance, gave a visual picture of a hilltop, then the motorized phrase, "Top of hill," then another mental picture of a hill with disappearing base, then a mental picture of a flagstaff on the hilltop at home, then a visual picture of a top given to the subject as a present in his boyhood days, and memory of seeing it wound up and spun, with the memory of the singing noise which it made. Again the motorization of an exposed word would suggest another similar in sound, and the association would start from this. The word would sometimes be ded and associations taken from different parts; or the

word would be given different significations in different parts of the exposure time.

One of the most striking things brought out was the lack of association from connective and relational words, definitive adjectives, etc.; and the displeasure with which they came consequently to be regarded. They seldom aroused any ideas directly, and few associations of any kind except verbal ones, usually phrases of which they customarily form a part. Occasionally they gave evidence of setting the subject's thoughts in characteristic directions of expectancy; and doubtless the prepositions, especially, always had some very general influence in determining how the whole thought organism should face the coming related object. These vague expectancies were occasionally noticed by the subjects, particularly in the case of such words as "between," "into," etc. The whole feeling of the subjects toward these words and their inability to call up associations irresistibly suggested that the mind had no place for them as separate wholes, and that there was no normal way of thinking them except as more or less fused components of larger units; viz.: as parts of phrases, and perhaps sentences as they continually occur in reading.

Turning to the associations from words given in context, we find as their most distinguishing characteristic that they are far less variable. The mere statement that the word to be exposed is part of a reading passage limits the trend of association when no context has been given. The limitation extends further when the subject has caught the general topic discussed in the passage, and still further when the exposed word is given upon a verbal and ideational background formed by preceding context. In the case of the word "top," for example, after the mention of "web-weaving" the word "top" no longer suggests "top of hill," "flag-staff," "spinning tops," etc., but preferably the "top of a post or gateway," with "spider-situation" in mind, and a greater vividness of the suggested picture for its having already been partially aroused in expectation.

This difference in the trend of association is shown by all subjects, but much more by some than others; and it varies from time to time as the subject's greater or less interest made him more or less approximate the condition of normal reading.

The newly exposed word was usually mentally pronounced as before, and "fitted into the preceding," as was very often remarked by one subject; the new word contributing apparently toward a notion of sentence unity, to which each additional element added a needed part. Immediately following this there was in a majority of cases a filling out of the sentence or phrase so as to make sense with the preceding con-

text, and when this did not occur there was usually a "forward push," "forward tendency," "tendency to fill out," as it has been very frequently described by the subjects. All subjects have emphasized the strength and comparative constancy of this feeling, and mentioned it as perhaps the most striking thing to be observed in the experiment. It was not present in any considerable degree at the beginning of paragraphs, nor at the close of sentences and paragraphs. The "little words" (as the subjects came to call the words expressing relation, etc.), gave but little except this forward feeling and verbal associations. They seemed, as subject "A" remarked several times, to be but "verbal counters" in the sentence.

Subject "A" showed comparatively little tendency to visualize throughout the experiment. There was, however, visualizing of some of the main objects and scenes referred to in the passages read,—enough to form a vague background for the story, which seemed, however, in the main to be thought in verbal terms. Subjects "B" and "C," however, had more of the visual element, and the interpretative process with them seemed to be more or less independent and parallel with the verbal associative complex. In the story of the spider's weaving its web, for example, a visual picture of a spider was early formed, which was present throughout, though more or less modified to suit the different references to it as the story progressed. The spider was seen in a visual background that had different components fused into it in a kaleidoscopic fashion, as the story gave additional data; but no violent breaks were made. While this scene would pass out of the attention field sometimes as some substantive would call up scenes peculiar to itself, it constantly remained as a factor controlling the course of expectation and association.

This visualization was almost always static. The spider jnmping was visualized as the spider ready to jump or just alighted. The thought of motion, when mentioned at all, seemed to be one of tendency to movement in the subject's motor organism.

The agreement or disagreement of the exposed word with the trend of expectation produced by the preceding context was a matter of frequent remark by the subjects, and often of considerable feeling on their part. No matter whether or not the subject had consciously formulated his expectations, there was a feeling of rightness or wrongness about the sequences, which was expressed in judgments of fulfilled or disappointed expectation. That this disappointment or fulfillment of expectation was not caused merely by getting or failing to get the particular verbal form desired, irrespective of its intrinsic fitness, is evidenced by the frequent judgments that the given word

though different was "all right," "still better," etc. Sometimes the new word given really closed the sentence to the subject's expectation, and the author's appending some corollary caused displeasure.

It would be profitable, if I had time and space sufficient, to give a detailed account of the results of exposure by phrases of the article on "Tribal Religions." A few comments must suffice, though I hope to make more use of the data, and especially of the method of experimenting, at some later time.

In almost every case the phrase was first "read and motorized," as the subject put it. It would seem as though this meant a recognition of the visual form first with a closely following motorization; though just what the "read" meant was rather uncertain to both of us. The processes usually seemed simultaneous to the subject's introspection. (I might say the subject was a thoroughly trained observer). Following this there was almost always either a "fitting in" of the word-group with what preceded, or a "filling out" with some word or group of words; according (usually) as the exposed phrase made closer connections with the preceding or following context. The fitting in with the preceding would be expressed in such words as "joined with what came before;" "recognized that this was sense expected though not the words;" "felt the fulfillment of expectation though words were quite different from expected;" "Sense fell in with the expected sense;" "gave phrase its place in sentence as far as could;" "gave it its place as completion of sentence;" (these are from subject's dictation, paraphrased sometimes).

The filling out would not always be with definite words. It was often expressed as "tendency to complete," "tendency forward," "very strong tendency to fill out." Quite usually, however, definite words or phrases came to mind, completing what was given. The subject remarked on one occasion that this forward tendency was by all means the most prominent of the things to be observed introspectively. There was occasional dissatisfaction at the non-fulfillment of expectation.

The subject had shown comparatively little tendency to visualize in my previous experiments with him, and showed no more in this. He remarked on one occasion that throughout the experiment he was struck with the little amount of visualization as compared with the verbal association. On another occasion he remarked that the words served simply as "counters" till he got "the whole thing."

There was a vague general picturing of location of what was described, and some vague visualization of main scenes and characters. But for the most part by far the subject was concerned with words and their interassociations. There were in-

frequent tendencies to translate into other terms, as when "condemned" seemed to suggest a gesture of striking down with the arm. These translations were usually but incipient and rather intangible.

I feel the need of much more experimenting, and especially of much more time than I have had for reflection upon the associative and interpretative processes in reading, before attempting any final account of them. Provisionally and roughly, I should say that in reading there were two sets of processes, somewhat independent and paralleling each other: (1) a reading in terms of interassociated word and phrase units (themselves composed of interassociated sub-units), thought in a variously proportioned combination of visual, auditory, and motor elements; (2) a reading (or interpretation) in terms of direct representations of the realities with which the subject matter deals; a picturing in sense terms of what the words symbolize.

The relative prominence of the two processess varies greatly with the individual, and, of course, with the subject matter as well. The first is the constant process, is the major part of the performance for most readers; is the part which makes the heavy draft on the psychophysical machinery—is the fatiguing and delaying process. It is the *ding an sich* for the average reader.

The second process is a sort of dramatization in which the reader sees and hears and smells and tastes, and takes a part. Consciousness may almost desert the first process in its interest in the scenery of the second; yet this scenery is constantly being changed by the word-workers behind; and it may be jarred to confusion by a wrong arrangement of word or phrase.

Usually, however, and with some readers always, the first process has much of the consciousness. Here, however, with practiced readers at least, consciousness has mainly to do with the higher phrase and sentence units. The reader's mind has a complex tangle of interassociated words. Each word and class of words has its preferred associates; and when these come
he habitual sequences their perception is duly facilitated.
natter that given phrase or word group has never been
before. Its perception will be duly facilitated, and it will
itarily perceived if it is cast in a habitual form—if it has,
familiar sequences of object following preposition, or of
tive following appropriate adjective. Much of the whole
I believe, may be worked out from this point of view.
e been interested in noting the part which motorization
have in this higher knitting together of word-units
se or sentence-units. The word, with myself at least,
be motorized as soon as singly presented, instantly

when *seen;* and this motorization seems to help hold it in consciousness while it is combining with the other words into the higher unit, the phrase, which is then itself motorized (or in reading aloud is spoken) by one unitary effort.

It is well known that in reading aloud the vocal utterance follows several words behind the eye's fixation point. It seems to me, also, that in silent reading there is a similar phrase motorization (or auditization, or both as is most usual) following behind the eye, and *after* the perception and audito-motorizing of the single words.

(This, of course, has reference to readers who motorize; and it seems difficult to find readers who do not, in a greater or less degree.) The single-word motorization does not make so much noise in consciousness as the later and reinforced utterance as part of a phrase; but is truly there, to my introspection at least.

Of the second process I can give but slight account. Most words with which we deal in reading are concepts; not representing definite single realities, but having more or less vague abstract ideas which they symbolize, and which they may or may not call to consciousness when presented.

Most of these concept words, as relational words, verbs, etc., represent abstract ideas which are very intangible; of which little clear account can be given upon the most careful introspection. Doubtless in reading there is usually a vague consciousness of the generalized experience which these words represent;—but for the most part they seem to be in the reader's consciousness as mere words; translatable in some measure at the reader's will, but the reader seldom willing. The words representing particular realities or less generalized experience more often call up these their associates.

Much of the translating seems to come not from words singly perceived, but from the perception of phrases and sentences as wholes; the words acting as "counters" until blended thus.

I have been more and more interested in the verbal side of reading. It seemed at first as though reading was dead, inane,—really *not* reading at all unless there was constant translation into the realities symbolized; but I have found various good thinkers and workers in science who seemed to be predominatingly verbalists in their reading;[1] and I am not sure but that the most of us read by far the most of our words and phrases without appreciable translation.

Such verbal readers and thinkers may be analogous to a banker who does an immense business in terms of drafts, bank-

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[1] We might expect this when we recall the results of Galton's tests of the imaging power of men of science.

notes, checks, etc.,—controls all sorts of situations by them, is free to convert them into property or whatever else they represent, at any time; but would be much hampered if he actually had to do this converting very often. So such a reader carries on his reading and thinking in a kind of short-hand, uses a mental algebra, lives in a word-world, a world of symbols. He can thus be more systematic, precise, expeditious; and after all his method may not be so fundamentally different than that of the reader who habitually translates into images; for the latter is but a dealer in other symbols of the same realities; symbols which he takes comfort in thinking are more like the realities than those in which the verbalist revels.

Such use of words, however, cannot and should not come until a broad and deep basis for it has been laid in terms of experience with the realities and with the images which more nearly represent them. Words, except as they are correctly and intelligently convertible, are certainly most deceptive and dangerous symbols for the reader as for the thinker.

Practical Suggestions.

In concluding here what must remain an unfinished study, I am tempted to add a word as to the possibilities of improvement in arrangement of reading matter and in reading method.

I was led to the present study in considerable part (1) by chafing at the slowness with which we must traverse pages of books and papers, the mind appearing able to assimilate the thought much faster than the eyes can traverse the lines, or the voice the words; (2) by curiosity to know the immediate conditions of the peculiar fatigue caused by reading.

I am far from being able to conclude as to cause or cure of either condition. I am firmly convinced, however, that there is possible an arrangement of printed reading-units which will greatly lessen the work of the eyes and considerably lessen that of the mind, and which will increase the speed.

The present arrangement compels the eye to cover three or four times as much ground as is necessary to get its data. It causes unnecessary difficulty in "keeping the place," and causes a certain amount of continual distraction from the presence, in the upper and lower periphery of vision, of comparatively unrelated matter. This, however, is but a beginning of the arraignment which might be made of the present arrangement from the eye standpoint.

From the interpretation side, one of the serious objections is that the present arrangement makes "skimming" difficult and unsatisfactory. We have noticed the [illegible] -cy to read in larger and larger uni[illegible] much of our reading could [illegible]

This skimming should be but an enlargement of normal reading, proceeding by a somewhat regular series of omissions and resting places, in which, however, all the matter could be taken account of in some degree. At present, however, one who attempts to "skim" down a page must proceed in a kind of hurdle-race fashion, breaking across lines of which the full content is necessarily unknown; and violating at every instant reading habits which it has taken years to form. The arrangement that is finally found to be the best for ordinary reading, will, I believe, facilitate skimming as well.

Again, improvement is to be looked for in a more systematically and logically organized subject matter. The reader's habits of word and phrase association and expectation have not been consulted in composing in the past as they will be when the psychology of style has been made a matter of common knowledge. The fact that subject matter arranged to accord with the reader's reading-habits is read in one-half the time of matter arranged contrary to these habits, suggests the immense advantage that may come from studies in this field.

It may well be that greater speed will come through a better method of reading from pages even as now printed. I await with interest the appearance of some study of reading rate among persons who have been forced for any cause to use a purely visual method. I should expect that such reading could be done at a faster rate, though possibly with disadvantage in some unlooked for direction.

I have tried various devices for increasing my own speed in reading, and have succeeded with but one, viz., to get thoroughly alive to the subject and keep *trying* to read fast. This seems to cause associative work to be done more glibly; there is more "reading inside" with fewer clues needed from the outside, and so, probably, fewer and shorter eye-fixations. In any reading we construct the thought and the words anew from inside; and if we lazily wait to *do all* this constructing after each eye-full of data is given, there is much time lost, and much room given for extraneous and distracting mind-contents. Personally, I should be grateful if I had been given speed drills in reading for thought, in my public school days.

Any adequate treatment of the matter of fatigue in reading is out of the question until the analysis of the reading-process has gone much further; especially as there is much to indicate that the fatigue is a matter which concerns the brain as much as it concerns the eye; and that the cumbrous associative word machinery may have much to do with it for most readers.

Eye-fatigue will be considerably lessened if publishers of books and papers will more constantly observe certain minimum requirements as to size and thickness of type, spacing,

quality of paper, etc., upon which investigators are in practical agreement. As to the vertical separation of the lines (in printer's phrase "the leading") and line-length, there is some disagreement; but a tendency, on the whole, toward the shorter line-lengths and a reasonable amount of "leading." It seems preferable to some writers, however, as Javal, to enlarge the type at the expense of the "leading," if necessary.[1]

But the greatest lessening of fatigue, at least of eye-fatigue, may be expected when there has been an entire reconstruction of the forms in which reading units are presented to the eye. The fossils of form perpetuated by spelling[2] and printing traditions need to be ground in the hopper of common sense, and reformed in the light of science and of that same common sense; and it may be found, upon trial, that the idols which the spelling reformers have been seeking to overthrow are not more pernicious (or perhaps more tenacious ot life) than these which the printing iconoclast is soon to attack. At any rate, it is high time that we put the question whether we are doing the best that we can in our arrangements for inter-communication of thought by printed symbols.

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[1] On the subject of printing-norms, valuable suggestions will be found in articles by Javal (*Rev. Scientifique*, 1879 and 1881), Cohn (*Rev. Scientifique*, 1881), Sack, reviewed by Erisman in *Zeitschrift für Schulgesundheitspflege*, Nos. 4 and 5, 1898), Griffing and Franz (*Psych. Review*, 1896), Blasius and Ludicke (*Vierteljahrschrift f. off. Gesundheitspflege*, Bd. XIII, p. 432), Sanford (*Amer. Journal of Psych.*, I), Cattell (articles in *Mind* and in *Wundt's Studien*).

[2] Note, *e. g.*, that through the retention of the useless silent letters, the eye and the mind must deal with about one-sixth more data than is needed. See "The Spelling Reform," by Prof. F. A. March, published by U. S. Bureau of Ed., 1893.

STUDIES FROM THE PSYCHOLOGICAL LABORATORY OF THE UNIVERSITY OF MICHIGAN.

Contributed by W. B. PILLSBURY.

I. THE FLUCTUATIONS OF THE ATTENTION IN SOME OF THEIR PSYCHOLOGICAL RELATIONS.

By J. W. SLAUGHTER, A. B., B. D., Assistant in Psychology.

Since the first consideration of the fact of periodically varying intensity in the perception of minimal stimuli, no one has felt that any final word has been spoken. The matter was considered important as bearing on the ultimate theory of the attention during the historic discussion, beginning with Lange and ending with Pace, but afterward it was mentioned in the literature as one of the general facts of the attention compatible with almost any theory, all question of causality being left open. This state of affairs has a degree of justification if we remember that fluctuation is by no means the greatest phenomenon referred to when we speak of attention, a term covering a wide range of facts and of exceedingly indefinite connotation. If any one is so rash as to overreach in his inference, he will soon find his theory going to pieces before an advance along some seemingly unrelated line. So the cautious attitude is not to be entirely discouraged or distrusted. At the same time it is evident that any investigation of this kind must have as its ultimate purpose the elucidation of the most complex and hitherto most baffling problem in psychology, viz., that of the essential nature of the attention. Some are content to rest in general terms, as, for example, that attention is the activity of consciousness as a whole, basing their position upon some simple formula, as the law of relativity, without recognizing the fact that such a formula, perfectly sane as far as it goes, still goes only a little way toward elucidating the processes involved, until the limits and manner of its application are fully determined. The discussion referred to pivoted on a question arising from the analogy, useful for some purposes, but often misleading, which compares consciousness to the field of vision and makes a separation of the perceiving agent from the object perceived. Do the so-called fluctuations of the attention belong

to consciousness or to the contents of consciousness? Very few to-day would insist that this is a paramount question or that its answer would give a final solution to the problem of the attention. We may say that the attention is some form of interaction of the conscious contents, but various perplexing questions immediately arise. Is it not a mere figure of speech to speak of "contents" with a conjoined function of interaction? Is this interaction a process of reinforcement or inhibition or both? What physiological evidence can be brought in support of the view?

Experimental demonstrations, especially of a physiological kind, have come in very slowly in a field where they are most urgently needed. Still certain important additions to our knowledge of the physiology of the nervous system, coupled with modified views of the attention, which demand a basis in the facts of nerve function, render an orientation of the question unavoidable.

The facts to be dealt with are simple and familiar. If attention is given to any just noticeable stimulus, as the ticking of a watch held at the proper distance from the ear, the gray rings of the Masson disk, or slight electrical stimulation of the skin, a periodic variation between perceptibility and imperceptibility is noticed. These are the so-called fluctuations of the attention.

I.

Since the reviews of the literature bearing on the question are fragmentary and unequal, it will be of advantage to give a brief description of what has been done in this field. The phenomenon, already noticed by physiologists and physicists, was first systematically dealt with by Urbantschitsch in two investigations.[1]

In the first of these he found that when a clock is placed at such a distance from the ear that the ticking is just noticeable, a variation in the clearness of the sound, ranging from the distinct appearance of the separate strokes to entire disappearance, is perceptible, the transition being in some cases gradual, in others sudden. The same result was reached when the ear was closed and the sound transmitted through the bones of the head. On the basis of these facts, he concluded that the fluctuations have their seat in the acoustic nerve, which being subjected to continuous stimulation, soon becomes fatigued and recovers itself only after a certain period has elapsed. In the

[1] Ueber eine Eigenthümlichkeit der Schallemfindungen geringster Intensität. Centralblatt f. d. med. Wissensch, 1875. Ueber subjective Schwankungen der Intensität akustischer Empfindungen, Pflüger's Archiv. Bd. 27.

second investigation, Urbantschitsch experimented with the two ears at once and with subjects having defects of hearing, and reached the additional conclusion that the periods for the two ears do not coincide but alternate. The noise is noticed first on one side, then it seems to pass through the head and appears on the other side. In similar manner and with like results, Urbantschitsch investigated the other senses. If two points are placed on the skin at the "limen of twoness," the periods fall first above, then below, the limen. If the points are further apart, the fluctuation is between the two just as in the case of the two ears. If the two index-fingers are placed in hot water, the pain sensation is felt first in one, then in the other. He found that the same rule holds if two points of any sensory surface are affected by their specific stimulus.

The view of Urbantschitsch that the phenomenon depends on the periodic exhaustion and recovery of the sensory nerves, admittedly without support from what was known of nerve physiology, found an opponent in Nicolai Lange who investigated[1] the variations applying to them the name "fluctuations of the attention." His view was that the fluctuations were of central origin and depended in general upon the reinforcing function of the apperceptive activity. After establishing the periods as extremely short he proceeded to his crucial experiment which was to compare the periods found by applying minimal stimuli to disparate senses at the same time. It was found that the periods did not fall together but were separated by a definite interval. On the basis of this experiment, very questionable in itself because of the difficulty of attending simultaneously to disparate minimal stimuli, Lange drew the immediate conclusion that the fluctuations did not depend upon fatigue of the sensory nerves, as Urbantschitsch had thought, but must be referred back to the unitary activity of apperception. The first or negative part of this conclusion, as Eckener indicates, has a certain ground if we grant the accuracy of the experiment. The second part, as Münsterberg tells us with justification, throws the whole problem back upon an activity which, as Lange conceived it, lies partly or entirely within the region of the transcendental. Lange then proceeded to support his position with experiments on the familiar illusion of the steps and broken wall, finding that the fluctuations between the two fall approximately within the same time limits as those connected with minimal stimulation. Reasoning from the assumed fact that the change in the illusion is due to the varying power of reinforcement of the memory images of steps

[1] Beiträge zur Theorie der sinnlichen Aufmerksamkeit und der activen Apperception, Phil. Studien IV, pp. 390, ff.

posed at intervals of two seconds, it was found that the fluctuations could be lengthened to 11 to 14 seconds. The average was 12.3 with an average variation of 3.1 seconds. In the next series, a sound was made by an assistant every second, which caused the subject to close the eyelids quickly for a moment, making a scarcely noticeable interruption in the fixation. "A decrease to entire vanishing never took place." A quick voluntary closing of the eyes every two seconds produced the same result. The next variation was by the interposition of a gray covering which for a short interval completely hid the disk from view. "The effect is now entirely different, . . the vanishing appears much oftener than by normal, uninterrupted fixation." The average length of the fluctuations was 5.8 as against the normal 6.9 seconds. The same general results were reached by making other variations, such as the use of indirect vision, and moving the whole apparatus slowly in different directions. In the last series of experiments, Münsterberg investigated the connection between breathing and the fluctuations. When the respiration was in short gasps a distinct shortening of the fluctuations was noticed; a lengthened respiration gave a corresponding lengthening of the fluctuations. In the latter case there was often a direct correspondence between inspiration and vanishing, but not seldom the two proceeded with entire irregularity.

Münsterberg's theoretical conclusions will concern us here for only a moment as they will be noticed later on. Realizing that the intervention of a transcendental function of consciousness never suffices for a scientific explanation, he decided that the variation must lie in the region of "contents," *i. e.*, must have a peripheral origin. He accounts for the process in this way. The gray rings of the disk, standing out only in the slightest degree from the background, require exact accommodation and fixation. Any cause, either artificial or of the nature of fatigue, which produces a change in the tension of the muscles, necessarily renders impossible for the time being the perception of the rings.

In opposition to the view of Münsterberg appeared a series of articles, the first of which was by Eckener.[1] This investigation is important as bringing the apperceptive factor in the process strictly within the lines of scientific explanation. Münsterberg had practically admitted the transcendental element in making the separation between consciousness and the conscious contents, the first being in the process under consideration a fixed will to attend, a complex of numerous motives,

[1] Untersuchungen über die Schwankungen der Auffassung minimaler Sinnesreize. Hugo Eckener, Phil. Studien, VIII, p. 343.

etc., the second being the act of perception itself. Eckener in a rather rigid criticism shows the impossibility of this distinction.

What Eckener does, beyond the work of Münsterberg, is to extend the method of investigation to other sense-departments, and on the basis of these results and a careful introspective analysis of the conditions involved, draw the general conclusion that all the causal factors are of a central nature. In particular, he points out the close connection between the ease with which the memory-image of a sensation is kept in clear consciousness and the fluctuation of the sensation itself. The conclusion from this is that the general psychophysical condition which connects the memory-image with the actual process of stimulation must vary in some way before the fluctuations can appear. The causes of such a variation are not far to seek. They lie partly within the nature of consciousness itself as an organization of dynamic not static elements, partly in the activity of other sensations claiming a share of the attention. In other words, the reason for the fluctuations lies in the familiar phenomenon of distraction. The criticism we will here pass upon Eckener is that he states the conditions of the problem without giving a real solution. Suppose we grant that the process is of a central nature, how much nearer are we to an intelligible understanding of its real nature? The term *apperception*, as he understands it, has no clearly definable laws, and, until we can determine them, it is absurd to apply it for purposes of scientific explanation.

Pace, in a companion article[1] to that of Eckener, describes an experimental test of Münsterberg's conclusion that the fluctuations depend upon variations in visual accommodation. Working only with the Masson disk, he first establishes the averages for the normal vision of his subjects, then paralyzes the ciliary muscles by the use of atropin, and finds that, with the power of accommodation entirely lacking, the fluctuations proceed with only a slight variation from the normal. The obvious conclusion is that the essential conditions are central. The slight variation would indicate some kind of reciprocal action between center and sense organ, but as to the nature of this he gives no opinion.

In the investigation of Marbe,[2] carried on without knowledge of what was being done by Eckener and Pace, the position of Münsterberg is attacked from another side. "Die Theorie Münsterberg's . . . . ist nur haltbar wenn drei Voraussetzungen

[1] Zur Frage der Schwankungen der Aufmerksamkeit. Phil. Stud. VIII, p. 388.

[2] Die Schwankungen der Gesichtsempfindungen. Phil. Stud. VIII, p. 615.

erfüdlt sind: wenn nämlich erstens die Schwankungen nur bei ebenmerklichen Reizen eintreten; wenn zweitens die Reize, damit sie überhaupt sichtbar werden, exacte Accommodation und Fixation erfordern, wenn drittens die Schwankungen nur bei dunkeln Punkten auf hellen Grund stattfinden." On this basis, a few simple variations in the method of experimentation are sufficient to overthrow the opponent's position. What Marbe really does is to determine the fact that when the intensity of the stimulus is varied within the very narrow possible limits, in the case of visual sensations by changing the degree of brightness or the distance from the eye, a ratio is found between the degree of variation and the length of the fluctuations. With a stimulus of greater intensity or nearer the eye, the periods of disappearance are shorter. We shall refer to this again.

In the investigation of Lehmann,[1] the theories of the former writers are rejected as one-sided, and an attempt is made to analyze some of the physiological factors in the process. Following a suggestion made but rejected as improbable by Münsterberg, he studies by a simple experimental arrangement the relation of breathing to the fluctuation. In the case of slight electrical stimulation, it is found immediately that the curves representing the respiration and the course of fluctuations, are in large measure coincident. This is not so evident in the case of sound or light stimulation, but, by plotting the averages of a large number of experiments on co-ordinates divided to represent the different stages of a respiration, the general result is determined that the maxima of the fluctuations fall near the highest point of the inspiration. To account for the irregularity, Lehmann brings in other factors, in the case of sound, the related memory-image determined by Eckener, in the case of light, both the memory-image and Münsterberg's variation in accommodation. As to the precise way in which the respiration affects the fluctuations, we are left in some doubt. ". . . . . die Reactionen sind am haüfigsten in der Nähe des Inspirationsmaximums. Hier ist eben der Blutdruck am grössten, und von diesem Zustand muss angenommem werden, dass er für die psychophysische Arbeit des Gehirns günstig sei. Wir wissen ja, dass das Blut, während der Arbeit irgend eines Organes, demselber reichlicher zufliesst." No one will dispute the fact that any organ in activity, by reflex excitation of the vaso-motor center, receives a larger supply of blood. This is eminently true of the brain. But that the activity of the muscles of respiration should cause

[1] Ueber die Beziehung zwischen Athmung und Aufmerksamkeit. Phil. Stud. IX, p. 66.

a greater flow of blood to the brain does not appear from this process of reasoning.

The valuable investigation of W. Heinrich[1] regarding the influence of central processes upon the activity of the visual sense organ, contains two results of importance to our consideration.

(a) " Wird die Aufmerksamkeit nicht-optischen Eindrücken zugewendet, so wird das Auge akkommodationslos, es kann sogar eine noch stärkere Abflachung der Linse eintreten, wie beim Fernsehen."

(b) " Wird die Aufmerksamkeit von den optischen Eindrücken abgewendet, so ändert sich die Konvergenz der Augenaxen. Diese nähern sich der Parallelstellung."

Heinrich proceeds without critical examination to accept the peripheral explanation of the fluctuations, not recognizing the fact that, on Münsterberg's ground, so soon as the central factor is admitted, this interpretation is no longer possible.

This review of the literature affords us a basis for distinguishing three views regarding the fluctuations: that they have a central cause, that they have a peripheral cause, and that they have a purely physiological cause. Each of these is open to certain criticisms.

(1) The school of Wundt finds itself in the unfortunate position of being committed to the interests of a definite theory. This theory, notwithstanding the fact of its great utility, is still so general that facts referred to it are not really explained, and, like all general theories, is easily disturbed by any apparently antagonistic fact. The consequence is that its supporters approach every question with a certain degree of preconception, which shows itself in the present case. (a) The variation must be in the clearness and not in the intensity of the sensation. (b) The falling away from clear consciousness must be due to interference and inhibition by other conscious elements. (c) The explanation must be predominantly psychological. This last is a basis of a very valid objection. If the phenomenon is to be viewed purely from the standpoint of apperception, there is nothing to determine its periodicity but the nature of the conscious elements involved. These are admittedly of very unequal importance in consciousness. On the other hand, the fluctuations, in spite of their variations, show a significant degree of regularity. This would predispose one immediately to look for some rhythmical physiological process as a basis of explanation.

The peripheral theory of Münsterberg, on the other hand, has the advantage of being at first sight very simple and plausible. But to grant that the fluctuations depend entirely upon

[1] Die Aufmerksamkeit und die Funktion der Sinnesorgane. Zeitschrift für Psych. u. Phys. d. S., IX, p. 342.

fatigue in the accommodation muscles of the sense organ, is to grant the previous assumption that this mechanism is relatively independent of the central factors. No such isolation seems possible. First, muscular fatigue, after the researches of Mosso and Lombard, must be interpreted as exhaustion of the innervating center. If it is replied that this is a purely reflex process, then, secondly, we may adduce the well known fact of central control of reflexes. This was definitely proved in the case of the eye by the investigation of Heinrich noted above. The primary impulse must come from the central organs. Further the theory may be questioned on the basis of fact, as the results of Pace's experiments show. Our own work on Dr. O., mentioned below, enters in as a definite disproof.

A theory like that of Lehmann, besides being very indefinite in itself, describes processes which have no psychical counterpart, so, however useful it may be in other directions, does not lend itself to the explanation of a psychological phenomenon.

II.

Our experimental work took, as its point of departure, two facts derived from former investigations: (a) that the weight of evidence lay decidedly on the side of a central causal process of some kind; (b) that the general theories of the attention and apperception required physiological supplementation before they could give an adequate explanation of the phenomenon. This gave a determinate direction to the work. It was necessary,

1. To make an accurate, detailed study of the fluctuations in order to determine any characteristics manifested in their actual process of occurrence.

2. To study the connection between these characteristics and any physiological processes that might be found to influence them.

The experiments were begun in the fall of 1898, and continued for the greater part of two years. The following persons acted as subjects for all or part of the experiments: Prof. Pillsbury (P), Miss Earhart (E), Messrs. Vought (V), Kirtland (K), Stevens (St), Dr. Oliver (O), and the writer (S). All of these except O. had had considerable training in psychological methods of work. None of them except Prof. Pillsbury and the writer had any knowledge as to the purpose of the investigation. Each subject was given several days' training before his results were treated as trustworthy.[1]

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[1] Perhaps no kind of reactions are at first more indefinite than those in this field. The object obtained by the preliminary training was the reflex registration of *all* the fluctuations and the exact boundaries of each. The best test of adequate preparation was the subject's own feeling of satisfaction with his reactions.

In order to carry out the first of the objects indicated above, it was necessary to obtain the fluctuations in series of suitable length. For this purpose a long horizontal drum was used, covered as usual in registration experiments with smoked paper. A small stand, bearing the Marey tambours and electrical markers, was moved along the drum by a threaded rod, turning uniformly with the revolutions of the drum. In this way a continuous series, lasting as long as ten minutes, could be secured. The tambour recording the fluctuations, was connected by a rubber tube with another tambour provided with a pressure-key which was operated by the finger of the subject. Time was recorded by a Jacquet-Verdin clock, indicating fifths of a second. The minimal stimuli used in nearly all the experiments were the gray rings of the Masson disk, as they were found to be most suitable for continuous series, as well as for furnishing the most unambiguous results. The disk used was of white cardboard and 26 cm. in diameter. Along one of the radii was a series of carefully outlined black spots, each of which was 4 mm. square. The distance of the spots from each other was likewise 4 mm. As the daylight was found to be exceedingly variable for the work, the reflected light of an incandescent lamp, carefully shaded from other parts of the room, was allowed to fall upon the disk. The distance of the subject from the disk was kept uniformly at one and one-half meters.

1. Normal Fluctuations.

The average time-lengths for the different subjects and different series were found to vary within such wide limits, that our original intention to make the individual fluctuations as occurring in a series the object of study, soon found sufficient justification. The time values were plotted directly on cross-section paper, a millimeter to the fifth of a second, those representing the visibility of the stimulus being above, those representing the non-visibility, below the horizontal axis. Distance was, of course, allowed on this axis for the lengths of both, reduced, however, to seconds. The general results will be evident from the following curve. The numbers indicate full seconds.

This curve is taken from the very earliest series, but the same characteristics are shown throughout. The characteristics are evident.

(1) The curves representing the visibility and the non-visibility of the stimulus do not remain constant but vary in approximately definite periods of two kinds, the first from 10 to 15 seconds, the second from 60 to 80 seconds in length.

(2) These variations seem, in a measure, independent of the number of fluctuations.

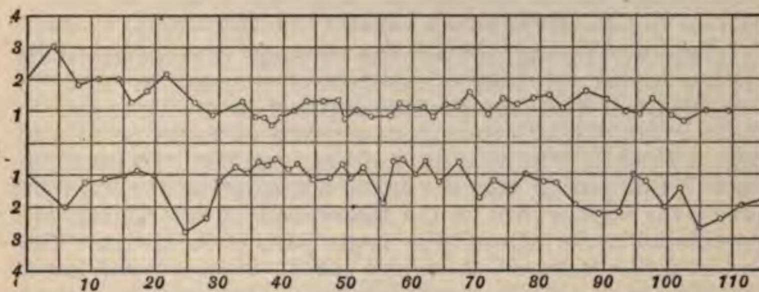

FIG. 1. SUBJECT P.

(3) The periods of visibility and non-visibility vary their length with reference to each other not in inverse but in direct proportion.

(4) In general, as the curves approach each other, that is, as the periods both of visibility and non-visibility shorten, the former seems to be relatively greater in length than the latter.

These generalizations are based upon the results of about forty series, of which the short section reproduced is considered representative. While these data afford very meager evidence for any kind of general conclusion, still they give certain suggestions which it may be pertinent to indicate.

(a) The fact that we find in addition to the primary fluctuations a secondary and a tertiary period regularly recurrent and largely independent of the number of fluctuations, would suggest that we are dealing with a composite process, showing the influence of several distinct physiological rhythms.

(b) The fact that a period of visibility is attended by a proportionally long period of non-visibility suggests the erroneousness of the commonly accepted view that the length of time a stimulus is effective in consciousness is a direct measure of the efficiency of the attention. If we can assume that the ratio of attention-efficiency is the ratio of the preponderance of the time-lengths of visibility, the converse seems to be the case. The most effective attention is attended by short and therefore rapidly recurring fluctuations. This position is sustained by the investigation of Taylor carried on in the Michigan Laboratory the past year. The experiments were sufficient at any rate to confirm our original opinion that the fluctuations are of central origin but incapable of explanation on a purely psychological basis, moreover, that the investigation of the physiological processes involved would be an analysis of the groundwork of the attention.

What Marbe designs to show by the Table is that the efficient perception of the stimulus varies with the distance of the object. He found the same true with variations in the brightness of the object, and summed up his conclusions in the formula that the fluctuation lengths are a function of the intensity of the stimulus. A comparison of the two Tables will show that our results are in close agreement with his except that in the ergograph series the periods of visibility are also shortened. As to the main point, as shown in the last columns, there is substantial coincidence. The conclusion from this is that muscular effort has the same effect on the fluctuations as an increase in the intensity of the stimulus.

How is this to be explained? Without anticipating more general theoretical conclusions, it may be said that the probable explanation is the same as that of the increase in the efficiency o a motor activity by other motor activities. In other words, that impulses emanating from motor cells act upon sensory cells by way of increasing their excitation. It is probable that some of Münsterberg's results, *e. g.*, the shortened fluctuations with rapid breathing, and the shortened periods of non-visibility with eye movements and quick closing of the lids, can be explained on the same basis as being due to the exertion of effort. Another apparent effect was that the subject could see the fainter rings at the periphery of the disk during the dynamograph or ergograph series, which were invisible during the normal series. This cannot be stated positively as it might have involved an element of suggestion.

An additional fact that may be noted in this connection is that the increased efficiency shown in the ergograph series is the same as the lowered limen of sensibility under the condition of maximal attention. The close connection between maximal active attention and strain sensations resulting from motor activity, hardly needs to be indicated. The bearing of the general questions of distraction and apperception upon what has been said, will be noticed in a later connection.

3. Relation to Vaso-motor Periods.

The investigation to this point has been concerned with what seems to be merely extraneous influences upon the course of fluctuations. The question now arises as to how the fluctuations themselves are to be explained. Is the process that causes them different in kind from the processes that influence their variable lengths? To pass over now to the purely psychological view of apperception would be a violation of the common psychophysical assumption of parallelism. Our further experiments answer the above question in the negative.

At this time an investigation[1] was being carried on in the physiological laboratory by Professors Lombard and Pillsbury relative to the changes in the rate of beating of the normal human heart. Distinct periodic changes in the pulse rate were made out, which were found to stand in constant relation partly to the respiration and partly to the Traube-Hering waves. The only possible explanation seemed to be that various impulses notably from the vaso-constrictor center flow over and act upon the vagus center, the effect showing itself immediately in an inhibition of the control apparatus and consequent accelerated action of the heart.

These experiments called our attention to the approximate equivalence in time existing between the fluctuations and changes in heart-rate, and at the same time showed a type of nerve activity that might possibly be a means of explanation. Since the changes had, as indicated, been traced to vaso-motor activity, it was determined to try the fluctuation series in connection with the vaso-motor changes. For this purpose it was necessary to alter slightly the arrangement of the apparatus. The curves were registered on the vertical drum of an ordinary kymograph, driven by clockwork. The rate of revolution was adjusted so that the fifths of seconds indicated by the time-marker were just distinguishable. This slow movement required a sharply outlined registration of the beginning and end of each fluctuation, so, instead of the tambour and pressure-key, an electrical marker was used. An ordinary telegraph key served to make and break the current. The various changes in blood-pressure were registered by means of a delicate piston-recorder[2] connected with a finger-plethysmograph. The point of the piston-recorder was kept on an exact vertical line with those of the time-marker and the marker indicating the fluctuations. The plethysmograph was surrounded by a water-jacket through which a stream of water of constant temperature was passed. This arrangement served to register the pulse, the respiration periods, the Traube-Hering waves, and all other changes in volume. The record varied with the different subjects, and with the same subjects under different circumstances. At one time the pulse only would be distinguishable, at another time, the respiration or Traube-Hering waves, so that it was only under the most favorable circumstances that a record of all the changes could be secured at once. The pointers were placed on the same line, and a direct comparison of the parallel tracings was possible. Attention should be called to the fact that this method of experi-

[1] American Jour. of Phys., Vol. VII, p. 201.

[2] For a description of this instrument and its uses, see Amer. Jour. of Phys., Vol. VII, p. 186.

menting made it quite impossible for any predisposition on the part of the subject to influence the validity of the results.

The tracings reproduced in Figure 3 will illustrate the method and the result reached by it. The upper curve indicates time in seconds; the middle one, the series of fluctuations, the raised parts corresponding to the periods of visibility; the lower shows the changes in blood-pressure, only the pulse and Traube-Hering waves being distinguishable.

Fig. 3. On S.

The coincidence of the periods of visibility and those of increased blood-pressure in the finger is immediately evident. This was substantiated on subjects P. and S. by about fifty series on each. The reason for such an extensive experimental test is that it was exceedingly difficult to keep the circulatory conditions sufficiently uniform to obtain a continuous series of vaso-motor effects. The lever of the delicate piston-recorder was lowered with the slightest variation in conditions of sound or light, or the intrusion of any foreign idea into the subject's consciousness. In estimating the results, only those sections of the tracings showing distinct waves for five or more successive periods, were treated as evidence. The following method was observed in reading the tracings. The plethysmograph curve was levelled up to a straight line directly under the fluctuation curve, by means of dividers separated to the exact length of the piston-recorder lever. This made it possible to compare directly the two curves with a view to determining their coincidence. A case was treated as one of coincidence when the period of visibility began during the rise of one blood-pressure wave and ended before the beginning of the next. Every case in which the period of visibility began during the decline or reached over to the next, or in which there was a fluctuation without a corresponding blood-pressure wave or *vice versa*, was treated as a contrary case. The general estimation of the readings, made under the above restrictions, shows the following rate of coincidence as compared with all the cases:

For subject P., 83% in 106 cases.

For subject S., 90¾% in 258 cases.

The presence of even these few contrary cases might throw doubt upon any conclusion based upon the results, but it must be remembered that there are many sources of interference quite beyond experimental control. There is always the possibility of a slight inaccuracy in the subject's registration of the fluctuations. Again, as we have already seen reason to believe, there are probably other physiological processes that exert an influence upon the length of the periods.

In the course of our experiments there appeared, in addition

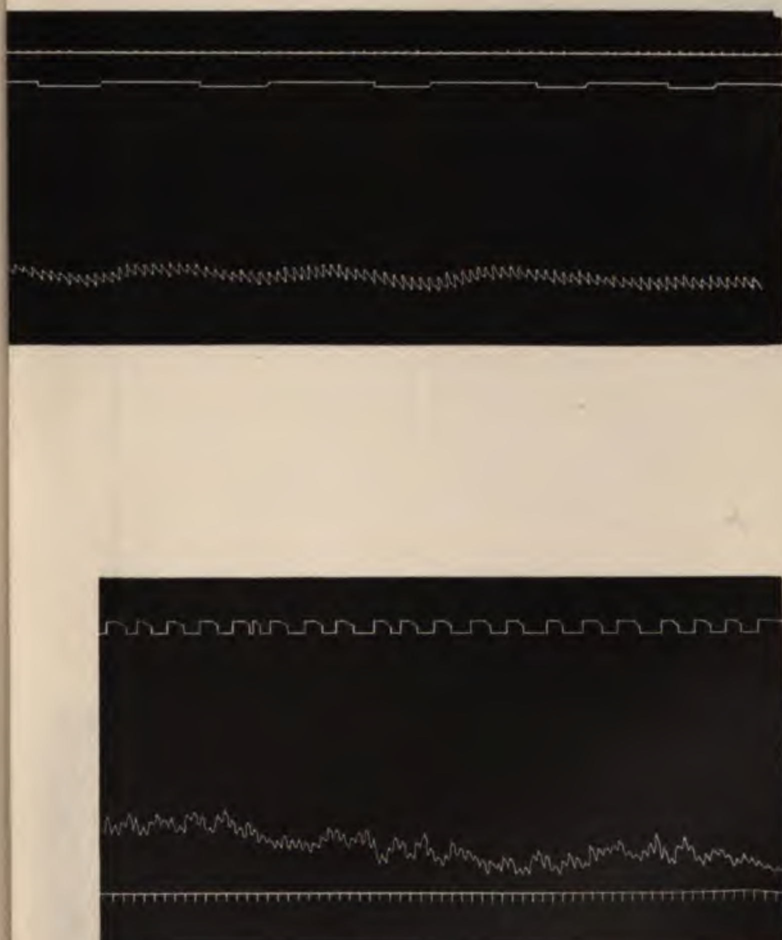

Fig. 6 on St.

follow accurately the periods of respiration. Then a subject was tried, who had been trained before but not used on account of the extreme shortness and constancy of his fluctuations. Only the plethysmograph was used, on account of the possible suggestion that might be given by the pneumograph. The result showed a strong pulse tracing and an extremely marked respiration wave. There was little or no indication of the Traube-Hering waves. The fluctuation periods corresponded closely with those of respiration. There were at in-

Fig. 6. On St.

tervals breaks in the correspondence, but this is what would be expected from the interference of the longer period. When the subject was questioned at the close of the work, he stated that he had been perfectly unconscious of the respiration process, that a connection between breathing and the fluctuations had never occurred to him.

The results here are in agreement with those of Lehmann who found in the case of minimal electrical stimulation an almost perfect correspondence between the fluctuation and respiration periods. The ambiguity in his method of explanation has already been indicated.

One important result to which this section brings us, is the complete uselessness of attempting to establish an absolute value for the fluctuations. The physiological influences that control them seem to differ widely with the various subjects and for the same subject at different times. This probably also accounts for the disparity in time values obtained from different sense departments.

The general results of our experiments would show, then, that the fluctuations of the attention are in close connection with at least three physiological rhythms. That in most subjects they run parallel to the Traube-Hering waves of blood pressure, as Exner has suggested might be possible.[1] That in some subjects the breathing undoubtedly plays the predominant role, and that in one subject it is probable that there is still another longer wave that assumes the more important place. Furthermore, even in the subjects whose main rhythm corresponds to the Traube-Hering waves the other influences are not entirely lacking. As Lehmann found, and his results are confirmed by the work of Taylor, even the longer attention waves tend to change their direction at a definite point in the respiration rhythm. Again, careful observation shows that the breathing rhythm continues to bring out the gray rings during the time occupied by the trough of the Traube-Hering wave.

[1]Exner: Entwurf zu einer physiologischen Erkärung der psychischen Erscheinungen, p. 303.

On the other hand the longer waves, whatever their origin may be, betray their influence in the varying lengths of the fluctuations corresponding to the Traube-Hering waves.

The interaction of these varying influences, now one, now another predominating in the different individuals and in the same individual at different times, would account for the variations in length, the limits of which have been set by Pace as 3 and 24 seconds.

5. The Case of O.

The present section has little connection with the above series of experiments, but should be appended as the description of an interesting case in connection with the old discussion as to the origin of the fluctuations. *O* was troubled by cataract in both eyes. In an operation taking place in July, 1890, the lens of the right eye was punctured, resulting in degeneration. The entire lens was removed in two subsequent operations. The same series of operations had been begun upon the left eye which, however, is not yet effective for seeing.

Owing to circumstances it was impossible to give much preliminary training, or take a very extensive series of experiments, so the reproduction of figures will have only a relative value. The averages found are:

Whole fluctuation, 6.72 sec.
Period of visibility, 4.89 sec.
Period of non-visibility, 1.83 sec.

The main point of interest is that the distinct appearance and disappearance of the gray rings took place just as with a person of normal vision. With the absence of the power both of convergence and accommodation, the result bears conclusively upon the peripheral theory of Münsterberg, and especially upon Heinrich's rather dogmatic support of it.[1] It again possesses a decided advantage over the results of Pace as he could never be absolutely certain that the atropin had entirely destroyed the power of accommodation.

III.

That nerve cells interact in some way, and that the activity of large groups of them can be focussed in definite directions, is an assumption that lies at the very basis of all psychological investigation. So long as no question as to how this activity goes on is raised, the assumption is granted without contradiction. The existence of the suitable anatomical structures is sufficient evidence that it takes place. One definitely proved physiological fact would go far toward settling psychological

[1] Die moderne physiologische Psychologie in Deutschland, pp. 125, ff.

disputes as to reinforcement and inhibition. There are, to be sure, a few special kinds of nerve activity which are intelligible to the physiologist. For example, (a) the transmission of sensory and motor impulses from one neuron to another; (b) the inhibitory control of certain reflexes such as those of micturition, parturition and defecation; (c) the flowing over of impulses from a sensory to a motor center, such as the fact discovered by Schäfer that stimulation of parts of the occipital and temporal cortex is followed by definite movements of the eye.[1] Investigations throwing light upon the influence of psychical states upon nervous activity are scarce but not entirely wanting. For example, Lombard has shown that the knee-jerk is reinforced by attention, mental work, music, etc.[2]

Our own investigation of the vaso-motor processes and voluntary effort, cannot be said to prove conclusively the additional fact that the activity of motor cells reinforces the activity of sensory cells, because one of our terms was a psychical state probably involving a number of factors, but the connection between this state, primarily bound up with a sensory process, and the motor activities mentioned is unmistakable. It might be argued regarding the connection with the vaso-motor process that the increased efficiency of the attention during the period of visibility is due to the increase in blood supply. This is the position of Lehmann, in the way of which there are certain very definite difficulties. In the first place, Lehmann takes as the basis of his theory the fact that when any organ is active it receives a larger supply of blood. From this he immediately concludes that the rhythmical respiration process alters the supply of blood to the brain. All that can be concluded from the premise is that the alteration is in the supply of blood to the respiratory organs. In the interval it may go to the brain or may not. Again, on his basis the impulse which serves as a demand for increased supply must originate in the activity of the organ itself. Consequently the periodic presence of a larger amount in the brain assumes a *prior* periodic increase in brain function, which puts the problem further back. In the third place, without attempting to dogmatize on the matter, it is almost safe to say that the rhythmical Traube-Hering waves, with which we found the fluctuations connected, are not the result of a specific demand from any part of the body. When such demand is made, the registration of these waves is interfered with, as was seen in our experiments in the instant fall of the lever when effort of any kind on the part of the subject took place.

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[1] Proceedings of the Royal Society, 1888, Vol. XLVIII.
[2] *Amer. Jour. of Psy.*, I, 1.

One other question stands in the way of our making a definite affirmation in regard to vaso-motor activity, viz., the unsettled difference between the positions of Mosso[1] and Howell concerning contrary circulation. If the supply of blood in the brain is the reverse of that in the body, then obviously in our case some cause for the fluctuations other than the presence of blood must be looked for. On the other hand, if the circulation is direct in both body and brain, the blood supply factor may enter in. But granted that the latter view is correct, the question still remains as to whether the presence of more blood has any effect whatever upon the function of nerve cells.

The phenomenon seems most explicable when put on the same basis as the fact that respiration waves are found in blood-pressure tracings, and that both respiration and vaso-motor effects are found in the rate of the heart. That is, the two centers, controlling functions of enormous importance and extent, must originate correspondingly powerful impulses, and these impulses not only proceed along their regular paths but overflow to other centers and are transmitted to the cortex, there acting by way of added excitation upon groups of sensory cells. The question might be raised as to whether, granting an influence of some kind, the impulses reinforce the process of stimulation or add to the energy of the cell. The question, however, is not important, for us the significant point being that *they in some way reinforce the functional activity of sensory cells.* We have already indicated the fact that sensory stimulation has the same effect upon the fluctuations as voluntary effort. So our general conclusion would be that the activity of any group of cells is not only a direct response to the stimulus, but is in large measure dependent for its efficiency upon the reinforcing influence of other groups of cells.

An objection to this position may be based upon the question of distraction. According to the Wundtian position, distraction, as seen in the apperceptive struggle of ideas, lies at the basis of the fluctuations. Eckener, as the exponent of this position, gives a long list of the possible influences claiming attention. Prominent among these are mentioned the sensations arising from the general stimulation of the sense organs disregarded for the time being. The objection is answered by the investigations of Miss Hamlin[2] and Münsterberg,[3] who showed that these influences, so far from being detrimental to the activity of the attention, are really necessary to its highest efficiency.

These results are in entire accordance with the type of ner-

[1] Ueber den Kreislauf des Blutes im menschlichen Gehirn, 1881.
[2] *Amer. Jour. of Psy.*, VIII, p. 1.
[3] Psy. Rev., I, pp. 39, ff.

vous activity to which our experiments on the whole seem to point. They further seem to furnish the best method by which to approach the general question of apperception and the mode of its activity. The view which regards the apperceptive relations of ideas as based entirely upon inhibition, is founded upon a kind of mental mechanics not at all consonant with the facts of nerve physiology. Inhibition is certainly one of the functions of the nervous system, but the word is used with reference to the effect and not the process. Nor is the position in agreement with the results of the investigations of Münsterberg and Miss Hamlin just mentioned. We naturally deal with the question from the point of view of our own experiments. While our results are not sufficient to warrant the final affirmation of a theory of reinforcement, still the facts regarding nerve function, the basis most needed for any kind of theory, point decidedly in that direction. The affirmation of the importance of this side has been definitely made by Exner and others of prominence. The view makes most intelligible the fact of unified interactivity of conscious elements, and at the same time saves us from the difficulties incident to regarding the attention as a special process.

Summary.

The results of the investigation, stated generally, are:

1. The fluctuations of the attention do not depend, as formerly affirmed, upon either the apperceptive process or changes in the sense organ.

2. The periods do not remain constant but have a definite order of variation.

3. Voluntary effort shortens the fluctuations and increases the relative efficiency of the attention.

4. The periods stand in close relation with the vaso-motor and respiration processes.

5. The causal process is physiological in nature, and probably acts by way of a reinforcement of the activity of the nerve cell, not indirectly through changes in nourishment, due to variations in blood pressure.

II.

THE EFFECT OF CERTAIN STIMULI UPON THE ATTENTION WAVE.

By R. W. TAYLOR, M. A.

The dominant place of attention in consciousness gives great interest to all experiments along that line. This paper deals with one of the minor phases of the duration of the attention. Our more particular problem was to investigate the influence of certain stimuli upon the length of the attention waves in the hope that the results would throw some light upon the much disputed question as to whether the waves were of central or of peripheral origin.

The Masson disk was used to give the minimal stimulus necessary, as it is at once more easily manipulated and the results obtained are less likely to be influenced by distracting stimuli than if a minimal sound or pressure is chosen. In these experiments the disk used was 32½ cm. in diameter, and had drawn upon one radius 15 dots, each 5 mm. long, 4 mm. wide, and separated from each other by spaces of 5 mm. The fluctuations were recorded by a Marey tambour upon the horizontal drum described by Slaughter.[1] At the rate used a single record lasted 8¾ minutes. The time was recorded in fifths of seconds by a Jacquet-Verdin chronograph. The reagent sat at a distance of two meters from the disk. Pressure upon the receiving tambour marked the time of appearance of the gray lines, and relaxation of pressure the time of disappearance.

The experiments were begun in February, 1900, and continued until June of that year. Mr. Schiller (S.), Mr. Bair (B.) and Miss Earhart (E.) acted as subjects. All had had some previous psychological training, and were careful, interested observers.

We shall consider the results obtained from S. first. The experiments were performed by taking a series of readings under normal conditions lasting over a period of three or four minutes, and then one or two series of readings under the influence of different kinds of stimulation during the last four or five minutes. The stimuli used for S. consisted of the pain from an induction current applied by dry electrodes to the left

[1] This *Journal*, p. 313.

hand, the complex set of impressions obtained from smoking, and the odors of balsam and ether. The induction current was adjusted to give a decidedly painful sensation, but of course it was impossible to obtain any measure of its strength or even to keep it constant during the experiments. The smoking was peculiarly pleasant to S. as he had been an inveterate smoker, but had abstained for some months before the experiments. It is not meant that this gave a pure sensation of any kind or that the experiment is not complicated by the direct narcotic effect of the tobacco. As will be seen in the discussion of the results we are concerned only to show that the attention waves respond to various influences in much the same way that the better understood physiological rhythms respond, rather than to trace accurately the effect of definitely isolated stimuli upon them. Only one tracing was taken with the odors, and the odors chosen were some that happened to be on hand, and are not those likely to give the most typical results. The same objection is of course to be brought against the ether as against the nicotine, and can be met in the same way. The results obtained from odors are only of value in confirming those obtained from other substances.

The results of the experiments on S. are given in Table I. The first three columns show the time in seconds of the visible period, of the period of invisibility, and the total period under the normal conditions. The second series of three columns gives corresponding values obtained during stimulation by the induction current, and the third series, similar values while smoking. At the bottom of the Table is shown the result of the stimulation by the different odors. Each tracing is given separately with its date, that the variations from day to day may be noted. Each tracing contained from eighty to ninety complete waves, and the Table gives the results of 850 observations. Several of the early tracings were omitted that the training might be nearly constant throughout.

The most notable fact in the results of the experiments is that the length of the total wave is shortened by the electrical stimulation. It is also noticeable that the greater part of the shortening comes during the period of visibility,—the visible period is decreased in length more than a second, while the period of invisibility is only ¾ secs. less. The results of the experiments while smoking are no less marked than in the preceding case, but the changes are in the opposite direction. In these tracings the total length of the wave is very noticeably increased, but in the present instance the increase is entirely in the visible portion of the wave, while the period of invisibility is actually decreased. These statements hold not merely for the average as a whole but for the average of

TABLE I.

Duration of Attention Waves in Seconds.

Reagent S.

	Normal.			Induction Current.			While Smoking.		
Tracing Date.	Visible	Not Visible	Total	Visible	Not Visible	Total	Visible	Not. Visible	Total
Mar. 21 (8)	6.3	5.1	11.4	5.4	5.5	10.9	—	—	—
Apr. 2 (11)	4.5	3.8	8.2	—	—	—	6.9	3.7	10.6
Apr. 2 (12)	—	—	—	4.7	3.8	8.5	6.0	3.0	9.0
Apr. 4 (15)	6.9	4.4	11.3	—	—	—	9.6	5.2	14.7
Apr. 4 (16)	6.8	4.0	10.8	5.4	3.7	9.2	—	—	—
Apr. 12 (18)	4.8	3.7	8.5	3.3	4.5	7.8	6.1	5.0	11.1
May 2 (19)	6.3	6.5	12.8	3.8	4.8	8.6	—	—	—
Average[1]	6.0	4.9	10.9	4.5	4.5	9.0	7.1	4.2	11.3
				WITH ETHER			WITH BALSAM		
May 2 (20)	6.7	6.7	13.4	5.0	5.4	10.4	3.3	4.1	7.44

[1]Includes normal of 20 below.

each tracing separately. The single tracing taken with odors as stimuli shows the same general effect as those taken during the stimulation with an electric current, except that the results are even more marked. In both cases the first effect of the odor was to increase the length of the stimulation, but the second effect was to shorten it very greatly.

When it comes to a consideration of the effect of the stimuli upon attention efficiency it is evident that the results given in the Table do not afford a direct means of comparison. The length of the entire wave varies, not merely the length of one part. It occurred to us, therefore, that the ratio of the period of visibility of the gray rings to the period of their invisibility would afford a direct measure of the attention efficiency, under the varying conditions. The results were tabulated in terms of this relation and the results for all subjects are shown together in Table II. The figures show the quotients obtained by dividing the period of visibility by the period of invisibility.

It will be seen in the table that the effect upon the attention efficiency is just as marked and nearly as constant as was the effect upon the length of the attention wave. In every tracing we find that the average efficiency of the attention is decreased during the electrical stimulation and is increased during the time that the subject smoked except in the case of No. 18. This tracing had been preceded by another which was discarded because the pneumograph had been drawn tight enough to be uncomfortable. As S. had been smoking during a part of that tracing the second indulgence might be expected to be

TABLE II.

Efficiency of Attention Measured in Ratio of Visible to Invisible Period.

(Subjects S., E. and B.)

S. SUBJECT.				E. SUBJECT.			B. SUBJECT.		
Tracing.	Normal.	Induction Current.	Smoking.	Tracing.	Normal.	Induction Current.	Tracing.	Normal.	Induction Current.
8	125	97	—	13	115	123	21	236	262
11	119	—	187	14	150	87	22	214	253
12	—	126	204	24	158	133	23	222	284
15	158	—	184	25	151	183			
16	170	147	—						
18	130	73	123						
19	96	81	—						
20	100	—	E[1] 92 B[2] 81						
Ave.	125	102	170	Ave.	143	134	Ave.	223	267

[1] Odor of Ether. [2] Odor of Balsam.

less pleasurable. The smoking also had immediately succeeded the electrical stimulation, and it is probable that there had not been sufficient time allowed for complete recovery from that effect. The two odors also show a reduction of attention efficiency, but again the observations are so few in number that they can be regarded only as confirmatory in character.

The results from E. show variations from those just reported, and are on the whole not so unambiguous. The results as regards the length of the waves are brought together in Table III. The effect upon attention efficiency is shown in Table II above. The Table itself is easily understood from the descriptions of the preceding Tables.

TABLE III.

Duration of Attention Waves.

E. Subject.

	NORMAL.			WITH INDUCTION CURRENT.		
No. and Date.	Visible.	Not Visible.	Total.	Visible.	Not Visible.	Total.
13 (Apr. 2)	10.1	8.8	18.9	14.6	11.9	26.4
14 (Apr. 2)	12.2	8.1	20.3	10.2	11.7	21.8
24 (May 7)	19.4	12.3	31.7	18.9	14.3	33.2
25 (May 7)	19.3	12.8	32.0	24.5	13.4	38.0
Ave.	15.3	10.5	25.8	17.1	12.8	30.0

It will be seen that here again the effect of the electrical stimulus is well marked and constant but that it is in the opposite direction to that shown by S. There is a decided lengthening of the wave rather than a shortening. There is evident in these tracings the unusual length of the attention waves that Slaughter found for the same subject. If we accept his conclusions that the attention waves of E. are related to a different physiological rhythm it would be easy to explain the apparent anomalies in the results as compared with the other persons. There are also anomalies in the effect of the stimulation upon attention efficiencies. It will be seen that in two tracings the attention efficiency is considerably increased, while in the other two tracings recorded the efficiency is very markedly decreased. These anomalies can all be discussed to better advantage after we have considered the concomitant effect of the current upon the breathing rhythm.

Table IV gives the corresponding results for B.

TABLE IV.

Duration of Attention Waves.

Reagent B.

No. and Date of Tracing.	Normal.			With Induction Current.			After Stimulation.		
	Visible	Not Visible	Total	Visible	Not Visible	Total	Visible	Not Visible	Total
21 (May 3)	4.9	2.1	7.0	5.2	2.0	7.2			
22 (May 4)	6.0	2.8	8.8	6.8	2.7	9.5			
23 (May 4)	6.0	2.7	8.7	7.9	2.8	10.7	5.4	2.8	8.2
Ave.	5.6	2.5	8.1	6.6	2.5	9.1	5.4	2.8	8.2

Here we see that the results of stimulation are again marked, but are in every case directly opposed to those noticed in S. In each the wave is slowed and the attention efficiency is increased. The only explanation to be offered for this result is that B. is of a very phlegmatic temperament and in perfect health.

In general, then, we find that stimulation by the induction current affected S. by uniformly quickening the rhythm of the attention fluctuation and decreasing the efficiency of the attention, for B. it just as uniformly slowed the rhythm and increased the efficiency, while for E. the wave was uniformly lengthened, but the efficiency was now increased, and now decreased. Smoking (a pleasant stimulus) lengthened the waves and increased the efficiency of the attention for S. The others were not tested for pleasurable reactions as neither smoked and no definitely pleasant stimulus suggested itself. The general results are just as confused as have been the results of re-

TABLE V.

Comparative Effect of Stimuli upon Attention and Respiration.

Subject S.

No.	Stimulation.	Visible Period.	Non Visible.	Total Respiration.	Attention Efficiency.
16	Normal	6.7	3.9	3.8	170
16	Induction	5.2	3.8	2.4	136
18	Normal	4.8	3.7	3.6	130
18	Induction	3.3	4.5	3.0	73
18	Smoking	6.1	5.0	6.5	123
19	Normal	6.3	6.4	5.2	98
19	Induction	3.8	4.8	3.9	81
20	Normal	6.7	6.7	6.9	100
20	Ether	5.0	5.4	3.8	92
20	Balsam	3.3	4.1	3.7	81

TABLE VI.

Effect of Stimulation upon Respiration and Attention Waves.

Subject E.

No.	Conditions of Experiment.	Visible Period.	Not Visible.	Total Respiration.	Attention Efficiency.
24	Normal	19.4	12.3	5.7	158
24	Induction	18.1	14.3	3.1	133
25	Normal	19.3	12.8	3.7	151
25	Induction	24.5	13.4	3.7	183

TABLE VII.

Respiration and Attention Waves.

Subject B.

No. of Tracing.	Conditions of Experiment.	Visible.	Not Visible.	Total Respiration.	Attention Efficiency.
21	Normal	4.9	2.1	3.2	236
21	Induction	5.2	2.0	2.8	262
22	Normal	6.0	2.8	3.5	214
22	Induction	6.8	2.7	3.1	253
23	Normal	6.0	2.8	4.3	222
23	Induction	7.9	2.8	2.7	284
23	After Stimulation Ceased.	5.4	2.8	2.9	196

obtained by Slaughter on the effect of voluntary exertion, it would seem that we may distinguish four different effects of stimulation upon attention waves. The stimulus at a certain intensity, or with some persons, shortens the length of the waves and lessens efficiency, other stimuli or the same stimuli with other subjects lengthen the waves and increase efficiency,

still other stimuli or the same stimuli on other individuals lengthen the wave and decrease the efficiency, while in still another case (voluntary effort) the waves are shortened and the attention efficiency increased. In the light of these contradictory results it would seem that we must distinguish carefully between the two different aspects of the attention and must decide that the two effects are not due to the same agencies. If we should consider a single stimulus in its varying intensities it would seem that the first influence at slight intensities is to quicken the respiration, to lengthen the vaso-motor waves and to render the attention more efficient. With a slight increase in the stimulus the vaso-motor waves are shortened, while the attention is rendered more efficient. With a yet greater increase in the intensity of the stimulus the vaso-motor waves are shortened and the attention efficiency decreased. The respiration rate is quickened by all the stimuli that we used. This series would account for all of the results except two tracings from E., and as we have noticed repeatedly these might be accounted for by the fact that her attention waves are of a different nature from those of the other subjects.

Physiologically it would be very easy to explain the different reactions of efficiency and length of wave if we think of the reinforcement from the medullary centers as merely marking off the rhythm of the fluctuations, while the variations in efficiency of the attention are explained as due to direct facilitation or inhibition of cortical activity. Then the rate would be influenced by all the factors that affect the vaso-motor rhythm just as the heart rate or respiration rate is affected, while the efficiency would need to be explained as due to a direct reinforcement or inhibition of the sensory cells as on the motor side the knee-jerk is affected by all sensory and motor impressions. It is easily conceivable that a stimulus strong enough to shorten the rhythm of the vaso-motor center would merely facilitate the action of the cortical cells, and that the relative susceptibility of these different cells would vary from time to time in the same individual and be different in different individuals.

We have not raised the question as to whether the intensity of the stimulus or its pleasantness or unpleasantness is responsible for the different changes that we notice, and our results are not sufficient to decide that question. We can at least assert that the feeling tone is only subsidiary, for we find that a decidedly unpleasant stimulus produces the same effect upon B. that a definitely pleasurable one has upon S. These and many other problems are suggested by our results, but we did not have time to go into them sufficiently to furnish a basis for discussion.

If we turn now to the direct bearing of our results upon the con-

troversy as to the nature and origin of the waves, the evidence is much clearer. The main thing in this connection is that the waves are influenced by external stimuli in very much the same way that the rhythms of heart and respiration are influenced. The direction of the influence and the nature of the stimulus are matters of very slight concern from this point of view. There is as much regularity in the effects as there is in the effect of similar stimuli upon either of the physiological rhythms or upon volume changes in the members.

But before we go on to our own explanation of the phenomena let us see if it is possible to explain the results in terms of either the Münsterberg[1] or the Leipzig theories. First as to the peripheral explanation. Is there any likelihood that a rhythm of fatigue and recovery in the muscles of accommodation in eye or ear could be influenced in one way by one kind of stimulus, in another way by another? There can of course be no direct effect upon the muscles in question, and even assuming that a muscle has a rhythm of fatigue and recovery that is of such short duration that it is very difficult to see how it could be affected by a central stimulus in the ways observed. Moreover, if there were direct stimulation we should expect it to show uniformity of results. As the action must be assumed to be of the same stimulus upon the same set of cells, the results from different individuals and at different times should be identical. Were the peripheral theory not already refuted by other facts it could offer no explanations for the phenomena that we have observed.

A very similar objection would hold against the purely central theory of Lange[2] that the fluctuations are due entirely to changes of the other ideas in consciousness at the time. This would go far towards an explanation of the oscillations in retinal rivalry, of the changing interpretation of figures in ambiguous perspective, and of the direction of the attention in general, but there is nothing at all in the ideas to account for a rhythm of any kind. If we lack a basis for an explanation of the fact of rhythm, we all the more lack any explanation of the changes in that rhythm under the influence of stimulation.

The simple Lehmann[3] theory would not be satisfactory because, in the first place, he did not hit upon the right circulatory rhythm and, in the second place, changes in blood pressure alone would not account for the variations in the efficiency, as all of the stimuli used would produce vaso-constriction while we see that they now reinforce, now weaken the attention.

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[1] Beiträge zur exper. Psychologie, II, pp. 69, ff.
[2] Phil. Stud., IV, pp. 390, ff.
[3] Phil. Stud., IX, pp. 66, ff.

All of our results on the other hand become intelligible if we accept Slaughter's[1] conclusions that the rhythm of the attention depends upon the re-enforcement of the cortical centers by the intermittent discharges from the medullary centers and add to his explanation the statement that the general tone of central activity is raised or lowered,—that the discharge of cortical cells is re-enforced or inhibited by the action of external stimuli. We already have an indication of the effect of irrelevant processes to re-enforce the attentive processes in the work of Professor Münsterberg[2] and Miss Hamlin[3] on distraction.

One interesting subsidiary result of the work in correlating the respiration with the attention wave was a confirmation of Lehmann's result that the changes in the attention tended to come near the beginning of inspiration. Our results are not quite so clean cut as Lehmann's, but for both S. and B. the great majority of the changes come either during or just after inspiration. For S. 83% and for B. 74% came within less than one-half of the curve following the beginning of inspiration. For E. again the results are not clear, but, nevertheless, rather more than half of the changes in attention fall within this portion of the curve. There was also noticed a tendency for the attention waves to cover even numbers of respirations over considerable intervals of time. Most frequently for S. two respiratory periods corresponded to one period of visibility and one to a period of invisibility. This changed under stimulation to one respiratory period to each period of visibility and invisibility. That there should be some such more or less definite relation follows as a corollary from the fact that changes tended to occur at definite times in the respiratory rhythm. Both relations are easily understood in the light of Slaughter's conclusions that the attention waves are due to overflows from the medullary centers to the central nervous system in general. Although the respiratory wave is not strong enough in itself to overcome the Traube-Hering vaso-motor wave, it nevertheless asserts itself at the beginning and end of the other. If the most active part of respiratory activity comes just before the longer wave is becoming sufficiently strong to bring the gray ring to consciousness, it will assert itself and make the impression visible before it otherwise would appear, and in the same way if the vaso-motor impulse is waning during the period of inspiration the respiratory re-enforcement will keep the rings in consciousness until the end of its period of activity.

These facts have some bearing upon the physiological nature of the vaso-motor rhythm. For if it is affected in one way by

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[1] *Amer. Jour. of Psy.*, as quoted.
[2] Psych. Review, I, pp. 39, ff.
[3] *Amer. Jour. of Psych.*, VIII, pp. 1, ff.

the stimuli while the respiration is affected in another way, it can hardly be regarded as originating in the respiratory center as Hering and Mayer have suggested.

SUMMARY.

1. The length of the attention waves is increased by stimuli of slight intensity, diminished by stimuli of greater intensity.

2. The efficiency of the attention, as shown by the ratio of the period of visibility of minimal stimuli to the period of invisibility, is increased by slight stimulation and decreased by more intense stimulation.

3. A large proportion of the changes in the attention take place during or just after inspiration.

4. The results of the experiments as a whole tend to confirm the theory that the attention waves are due to overflow effects from the vaso-motor and respiratory centers upon the cortical centers.

Our results suggest that the Traube-Hering and other circulatory rhythms can be more conveniently studied in man in their secondary form as attention waves than directly by the plethysmograph.

III.

DOES THE SENSATION OF MOVEMENT ORIGINATE IN THE JOINT?

By W. B. PILLSBURY.

Since Goldscheider's work on the 'Muscle Sense' there seems to be very general agreement that the joint is the only or by far the most important source of the sensations that inform us that we have moved the members of the body. Almost no question has been raised during the decade that has elapsed as to the absolute completeness and exactness of his results. During the last few years, however, the conviction has been growing upon the writer that some of this work needs revision or extension, and that the dominant part which is ascribed to the joint in the complex is not definitely proved to be deserved.

Goldscheider's analysis of the sensations received during passive movement makes it consist (1) of the sensations that arise from the rubbing of articular surfaces, together with wrinkling of the capsule; (2) strain upon the tendons of one set of muscles and relaxation of the tendons of the antagonists, and (3) change in the form of the muscles. A striking divergence in the facts of consciousness from what this analysis suggests is seen in the majority of subjects who work with the sensation for the first time in that the movement seems to be noticed first in the wrist or fore-arm, or even in the tips of the fingers. A possible explanation of this fact in terms of Goldscheider's theory might be offered if we considered the sensation in the wrist merely the result of an associative projection of the joint sensation to the part that is most concerned in the movement. This would bring it under the same category as the projection of sensations to the tip of the pen in writing, or to the end of the cane in walking. This was the explanation that was offered to the students, and that for some time seemed entirely satisfactory. On one occasion, however, it was suggested to two students who were suspicious about this explanation that they pass an induction current through the wrist and see if it had any effect. It was supposed that there would be no effect of any kind, but on the contrary it was found that there followed nearly as marked a decrease in sensibility as when the current was passed through the elbow itself. This observation was confirmed on several subjects and with several

successive classes until there seemed to be no longer any doubt that it would be profitable to work over the field again in spite of the general acceptance that is accorded to Goldscheider's conclusions.

Experiments were begun in November, 1900, and continued until the following January. Mr. Bair (B.), Mr. Stevens (S.) and the writer (P.) acted as subjects. All had had some previous psychological training. Experiments were made upon the elbow and knee joints only. The apparatus used was the ordinary passive movement apparatus, a hinged board to support the arm which was raised by a cord that passed over a pulley fixed in the top of an upright. To avoid the unevenness in speed that is necessarily connected with moving the board by hand we arranged to lift it by an electric motor. The speed of the motor was reduced by a worm gear and a series of pulleys. An ordinary clutch in an old bit of shafting served to interrupt the movement of the board without stopping the motor. The connection between shafting and arm board was made by an elastic cord. This served admirably to reduce the jerk at starting. The slack was taken up gradually, and the movement began almost imperceptibly. When once started the movement was at a constant rate. A pointer in the end of the arm board moved over a millimeter scale on the upright that supported the pulley and served to measure the amount of the movement of the arm.

In the first series of experiments the subject sat with the arm upon the board, with the elbow joint just over the hinge, the clutch was adjusted to start the board, and a signal was given as the arm began to rise. This time for giving the signal was adopted after several trials because it was the only one that permitted a constant interval to elapse between the time of giving the signal and the entrance of the sensation into consciousness. It could not be given when the clutch was adjusted to start the movement because it was impossible to keep the amount of slack to be taken up a constant. The movement was so slow (about 20′ per second) that it ordinarily took about two seconds for the movement to progress far enough to be noticed. The first series of experiments were taken with the arm normal, then a series was taken with the induction current passing through the elbow, a third with the current passing through the wrist, and finally several series with both elbow and wrist anæsthetic. In each case the current was passed as nearly as possible directly through the joint to be experimented upon. The results are collected in Table I.

In the Table the first pair of columns gives the results with the normal arm, the second those with the current through the elbow, the third with the current through the wrist, and the

TABLE I.

SUBJECT.	NORMAL.		CURRENT TO ELBOW.		CURRENT TO WRIST.		WRIST AND ELBOW.	
	No.	M.	No.	M.	No.	M.	No.	M.
B.	118	33′	81	1° 45′	70	1° 28′	85	2° 8′
S.	163	51′	76	2° 30′	68	1° 43′	76	6° 27′
P.	179	26′	68	1° 50′	68	2° 2′	70	2° 24′

last with the current through both wrist and elbow. The first column in each pair gives the number of experiments, the second, the average just noticeable movement. It will be seen that in every case there is a very noticeable diminution in the sensitivity to movement at the elbow when the current is passed through the wrist. In one case the minimal movement is considerably less than when the elbow joint is anæsthetised; in a second case is slightly less, and in a third case is slightly greater, but in no case is the average movement necessary to produce a sensation less than twice as great as that required in the normal arm. A confirmation of the result is found in the fourth series of experiments in the fact that when the current was passed through both joints at once there was a marked decrease of sensitivity as compared with either of the other conditions. Any suspicion that these results may be due to suggestion or may be artefacts of the method of procedure is removed by the facts that the sensitivity decreased constantly as the series of experiments proceeded, would increase again if for any reason the experiment was resumed after temporary interruption with the current cut off, and that the anæsthesia persisted with diminishing force for some time after the current had stopped.

The same series of experiments was repeated with the knee joint. In these experiments a very similar apparatus was used as for the elbow. The board used was long enough to accommodate the lower leg, the subject lay face down upon a table with the knee-joint just over the hinge. The lower leg was supported by the knee and the toes so that no other parts were in contact with the apparatus. The position was uncomfortable, and it was, therefore, necessary to give the subjects frequent rests to prevent excessive fatigue. The discomfort, however, would affect all results in the same degree, and so would not detract from the relative correctness of the results. The differences are also too large and too constant to be accounted for by any error of this kind.

The experiments were repeated for the knee in very much the same order and with the same results as in the preceding case. The results are shown in Table II below.

TABLE II.

Movement of Knee Joint.

SUBJECT.	NORMAL.		TOE ON SPONGE.		CURRENT THROUGH TOE		KNEE.		ANKLE.		KNEE AND ANKLE.	
	N.	M.	N.	M.	N.	M.	N.	M.	N.	M.	N.	M.
B.	239	1° 15′	—	——	—	——	85	2° 46′	97	2° 8′	86	3° 12′
S.	128	1° 27′	59	1° 18′	133	1° 18′	126	2° 46′	115	2° 46′	—	——
P.					123	41′	150	2° 22′	105	2° 11′		

Here, too, anæsthesia of the joint distal to the one moved had a marked effect in decreasing the sensitivity of the latter. The results are again usually not so great as in passing the current through the moved joint, but are not so very different from it. In the one case in which the two joints were anæsthetised at the same time there is again a marked increase over the effect upon either alone. For P. and S. this series was not taken as the other two were in complete agreement, and did not seem to need confirmation.

Incidentally in the series with S. we obtained an interesting comparison of the sensitivity of the skin and the deeper lying sense organs. S. noticed during the first series of normal experiments that there was a sensation coming from the skin of his toes, and feared that he might be making his judgment in terms of the tactual rather than of the kinæsthetic sensations. When the experimenter watched carefully it was seen that as the member was raised the toes were forced upward along the board rubbing the skin as they moved. This movement at times amounted to as much as two millimeters. To guard against this source of error the toe was first placed upon a dry sponge which moved along the board and saved the toes, which it supported, from the rubbing. It will be seen in the second column of Table II that the only result of this arrangement was actually to decrease the least noticeable movement. Fearing that there might still be some sensation from the skin that enabled the judgment to be made, the sponge was moistened and connected with one pole of the induction coil, another electrode was placed on the other side of the toes, and the current passed through. It will be seen from the table again that the result under these conditions gave exactly the same average as in the preceding case. The sensation from the skin, then, has apparently absolutely no influence upon the judgment. Under these conditions the limen for the tactual is either higher than or identical with the limen for the kinæsthetic sensations. The subject's impression that the judgment was in terms of the skin must have been due to the fact that the board was not

stopped quickly enough after he had made his judgment to prevent overstepping the limen for the tactual sensations as well as for the kinæsthetic, and the distinction between the sensations that came before and those that came after the judgment could not be clearly drawn. These experiments with current through the toe would also remove any possibility of the effect of the induction current being due to the distracting effect of the pain. Here we find the same strength of current actually resulting in an increased rather than a decreased sensibility, if we are to draw any conclusion at all from differences so slight.

The experiments upon B. had already been made before these observations, and in the light of them it did not seem necessary to discard the earlier ones. The experiments on P. were all made, assuming the results obtained with the current through the toe as the standard of reference.

Our results then go to show very definitely that the sensibility to movement in elbow or knee is decreased nearly as much by passing a current through the ankle or wrist as by passing it through the joint that is concerned. Our next question is as to how this fact can be explained in the light of what we know of the sensory nerve supply of the different parts, and how they can be brought into harmony with the results of Goldscheider in the same field.

It seems evident at once that the conclusions of Goldscheider that sensation of movement is mainly due to the excitation of the sensory endings in the joints by the rubbing of joint surfaces cannot be accepted without further investigation and modification. Certainly the nerves at the elbow are not likely to be rendered less sensitive by the passage of the current through the wrist, and on his premises there seems no possibility of any other explanation.

Let us turn to the anatomical facts in relation to the distribution of sensory nerves and see what light these cast upon the subject. The undisputed facts as to endings that may be concerned is first that there are highly developed sensory endings thickly scattered in the tendons, particularly in the zone of transition from muscle to tendon (Huber and DeWitt,[1] Golgi,[2] and others), that there are sensory endings in the tissue of the muscle, and that Pacini corpuscles are found embedded in adipose tissue between the tendons and muscles, and are particularly frequent in the neighborhood of the joints (Rauber).[3]

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[1]A Contribution on Nerve Terminations in Neuro-tendinous Organs: Jour. of Comp. Neurology, Vol. XII, pp. 159, ff.

[2]*Sui nervi nei tendini dell 'uomo*, etc. Memor. della R. Accad. delle Sc. di Torino; Serie II, Tomo XIII, 1880.

[3]Untersuchungen Ueber das Vorkommen u. Bedeutung d. Vaterschen Kőrper, München, 1865.

The sensory innervation of the joint is not so definitely made out nor so free from disputed points. The statement so frequently made in the text-books of physiology and psychology that the joints or joint surfaces are richly supplied with sensory endings seems to have grown out of Rauber's discovery that there were Pacini corpuscles in the neighborhood of the joints. This statement was, apparently, at first taken to mean indefinitely inside or outside of the joint capsule, then within the capsule, and, finally, on the joint surfaces. At least we could nowhere find any definite statement that sensory nerves were found on those surfaces, and where any authority was cited for the nerve supply of the joints the reference was to Rauber. Goldscheider gives no authority for his statement, and says definitely: 'Eine anatomische Untersuchung der Innervation der Gelenkenden wäre wünschenswerth.' Ivanhow[1] found sensory endings in the fasciæ and the capsules of the joints, but this seems to be the only well established histological evidence of sensory endings in the joints themselves.

In the same article Goldscheider[2] attempted to prove physiologically that the joint surfaces were sensitive, but with poor success. He exposed the joint surfaces in frogs and rabbits, and stimulated them by pressure and heat, in the hope that he might excite respiratory reflexes. His results were of a negative kind. He did call out reflexes when the bone was cut away to expose the marrow, but with the uninjured joint surfaces there was no definite response, that could not be interpreted as due to the transmission of the stimulation to the periost or to the marrow. He concludes, "Dass die Gelenkfläche selbst empfindlich sei, hat durch die Versuche nicht erwiesen können," but adds, "Aber auch ohne dieselbe darf wohl die Berichtigung, die Gelenkenden als Substrat einer Sensation anzusehen, bereits anerkannt werden." The grounds upon which he rests this conclusion in the earlier article are: first, the fact that the sensitivity is reduced by passing an electric current through the joints, then that all the other possible sense organs may be eliminated,—the skin because a superficial anæsthesia does not diminish the sensitivity to movement; the muscle and tendon because there is practically the same limen for all positions of the limb while the variations in the condition of the muscle must take place more rapidly in one position than in another. The first argument we are prepared to deal with later; that the skin does not serve as the organ, may pass without comment, while the argument that it

[1] On Nerve Endings in the Connective Tissue Capsules and fasciæ of mamalia (Russian). Dissertation, Kasan, 1893.

[2] Ueber die Empfindlichkeit d. Gelenkenden: Gesamm. Abhandlungen II. pp. 282, ff.

is neither muscle nor tendon, seems to have taken into consideration only the flexors, and to have forgotten the extensors, which would be affected in the opposite way in all respects, and serve to counteract any irregularities to be expected from the flexors alone, and also to have overlooked the muscles that were attached about the joint which do not serve to bend it. The evidence in favor of the joint surfaces as the seat of the sensation then is reduced to the fact that the sensitivity of the joint is reduced when the current is passed through it.

Our results cannot easily be explained in terms of Goldscheider's hypotheses, but can easily be brought into line if we assume that the sensation of movement originates in the tendon organs or in the Pacinian corpuscles which Rauber described. This becomes clearer from a glance at the arrangement of muscles and tendons that run from elbow to wrist, and from knee to ankle. Many of the large muscles, both flexor and extensor, have their origin above the elbow on the lower end of the humerus and their insertions at the lower end of the radius or ulna, in the metacarpi or even in the phalanges of the fingers. The upper tendons of all these muscles cross the elbow joint, and the lower tendons are thickly gathered together at the wrist. Any movement of the arm must tend to relax the tension on one set of muscles and tendons, and to increase that on the other set. Very similar relations hold for the lower leg. The sensations that are produced by these changes in tension would come from about the elbow and knee in part, but also in part from the wrist and lower forearm, and from ankle and lower leg. Anæsthesia of either set of tendons would then be expected to produce a decreased sensitiveness to movement, as we found in our experiments. Furthermore, we should expect that the current through the elbow and knee would have the more marked effect, as the tendons at the lower ends of the muscles begin to appear well up on the forearm and lower leg, and so a smaller portion of their length would be affected by the current, and, secondly, the tendons at the insertions of the muscles of the upper arm and thigh, biceps and triceps, *e. g.*, would be affected at the elbow and knee, and not at the wrist or ankle. Another set of organs to be affected are the Pacinian corpuscles described by Rauber. These are most numerous about the joints, and any change in the tension upon the muscles and tendons would also change the pressure upon them. Altogether, then, our results would be satisfactorily and completely explained on the assumption that it is the tendon and muscle organs, not the joint surfaces, that are the source of the sensations of movement.

If it is still insisted that the joints are sensitive and originate the sensation, it is only possible to explain the reduction of

sensitivity by the current through the wrist and ankle on the assumption that the muscles and tendons acted as cords, and that the displacement at the elbow or knee produced an increase or decrease in the pressure of joint surface upon joint surface at the wrist and ankle. Even if the joint were extremely sensitive it is hardly conceivable that the tendons could transmit sufficient energy to produce a noticeable effect there without exciting the delicate sense organs in their tissue. Particularly would this be the case if we consider the probability that there would be only a change in the disposition of the pressure upon the surfaces rather than a change in the amount of the pressure.

Looked at from every side, then, it seems very difficult to avoid the conclusion that the part of the sensation of movement which originates in the wrist is due to stimulation of the tendon organ. If we are forced to this conclusion in the one case, it certainly seems easier in the light of the doubt that surrounds the innervation of the joint to assume that the sensation from the elbow is also a tendinous or muscular sensation rather than one from the joint. The forces that stimulate the lower tendon are at work in even greater degree in the upper, and they are alone sufficient to account for the known effects. Any bringing in of joint sensation would at the least be entirely gratuitous. What part the sensory endings in fasciæ and capsule may play does not appear. However, from the fact that they are relatively less developed than the tendon and muscle organs, and that they are probably less favorably situated for stimulation, it would seem probable that they have a minor rôle.

Summary.

We find that the sensitivity of the joints is decreased by induction currents through wrist and elbow as well as by currents through the joints in question. This fact, together with the lack of anatomical evidence that the joints have sensory endings, makes it probable that the sensation of movement is derived mainly from the tendon and muscle rather than, as Goldscheider thought, from the joint.

THE EDUCABILITY OF THE PERCH.

By NORMAN TRIPLETT.

The material here presented is a brief summary of observations made in the spring of 1899 on the psychic life of fishes in captivity. Its chief interest lies in its being a modified repetition of the famous experiment of Möbius which has come to be regarded by some as one of the fairy tales of science. Bateson's account of the experiment is as follows:[1]

"The story runs that pike, having lived for some time in a tank separated by a glass plate from another in which small fish were living, desisted from trying to catch them, and on the glass plate being removed never attempted to do so. The suggestion is that the pike had come to believe these particular fish to be under special protection."

In the experiment to be detailed herein, two perch (*Perca Americana*), one of each sex, took the place of the pike. These fish had been kept in the laboratory in a tank, 4x2x1½ feet in size, for several months previous to the test given below. During all this time their only food had consisted of live minnows two or three inches in length. On beginning the experiment a glass partition was placed in the tank and their food changed to angleworms.

Instead of permitting the minnows to remain in the divided tank as Möbius did, I simply put them in for thirty minutes, and at the end of that time removed them again and gave the perch an allowance of worms. Experiments were made in this manner three times a week for nearly a month, on Mondays, Wednesdays and Fridays between the hours of four and five o'clock in the afternoon, and after that on every day at the same hour. In all experiments after the very first the observations were made from behind a screen through a narrow slit.

The notes taken on the various occasions would tell the story most completely, but to avoid unnecessary repetition, they have been condensed in the description following. On April

[1] W. Bateson: The Sense-Organs and Perceptions of Fishes, *Journal of the Marine Biological Association*, N. S. 1890, I, 225-256; see especially p. 243. The original account by Möbius in the *Zeitschr. Gesammt. Naturwiss.*, XLII, 1873, pp. 89-91, has, I regret to say, not been accessible to me. The same experiment is cited by Darwin in the Descent of Man, pp. 75-76, with a reference *Die Bewegungen der Thiere, etc.*, 1873, p. 11.

21st, the first day, I note: Two minnows were placed in the tank at 4.30 P. M. The perch immediately began ramming the glass to get at them. Their actions became more violent as the minnows approached the partition. They ceased their butting and swam away from the glass for a few seconds after seven minutes of continuous effort. A second trial lasting one minute followed, and this was followed in turn by still shorter periods. Greater energy was shown always when the minnows turned their heads toward the perch, as it is only when they are "head on" that the latter strike. At 4.55 the female was showing what seemed to be signs of anger, and was striking the glass hard. During all the subsequent trials she was the more persistent of the two, and several times seemed to show signs of rage, lashing the glass partition savagely. By five o'clock both perch had left the glass and seemed to have given up the attempt completely. At this stage the minnows were removed and the perch fed.

At the next trial their efforts were not so long continued nor so violent as on the first day, and the further history of this part of the experiment varies but little, the time and energy spent at the glass fluctuating somewhat from day to day, depending perhaps in some degree on the keenness of their hunger. Their efforts on Mondays were noticeably more determined than on Wednesdays and Fridays, because, it would seem, of the added day's fast. They never failed to try for the minnows to some extent, especially during the first half of the thirty minute period, but with waning energy and persistence. In this manner the trials proceeded for a month. On May 22nd I note: They pay no attention to the minnow till some time after I have placed myself behind the screen. They are less demonstrative than on any previous Monday.

I now determined to admit the minnow, and after the appetite of the perch had been dulled a very little with worms, the partition was removed. The minnow swam around with the perch, over and between them. Having lost its own mate, it perhaps sought companionship. The male paid not the slightest attention to it. The female, whose persistence at the glass has been noted, moved toward it several times, but whether from curiosity or with hostile intent could not be determined. She did it no harm however. On succeeding days the minnow was admitted in the same way, and the actions of the perch toward it were closely observed. On the second occasion they had been fed little and were still hungry. The minnow hovered near them as if for companionship, but all the time was a little wary. Several times they started to stalk it, but when within a short distance of its head would turn aside, the impulse being plainly inhibited in the face of repeated opportunity. In the

subsequent trials the perch were unfed. Their action, nevertheless, was always much as has been indicated. Sometimes they would swim around the aquarium apparently quite indifferent to the minnow, which accompanied them, but the sight of it moving in front of them would often stimulate the truncated attack already described.

The form of the experiment was now somewhat changed, being performed as nearly as possible after the manner of Möbius. The minnows, the one used before and a new one, were left for a week in the tank, separated from the perch by the glass. The latter ceased almost entirely to touch the glass, although quite frequently they took a position near it and watched the minnows playing on the other side within two or three inches of them. Their conduct when the partition was removed was exactly similar to that in the previous experiments.

Bateson, in the article above mentioned, suggests that the result of the experiment of Möbius may have been wrongly interpreted, and that "the explanation should be referred to that paradoxical instinct which is widely developed among animals of many kinds, in obedience to which they occasionally do not eat or molest those with whom they are constantly associated. It is, of course, this unexplained instinct upon which the 'happy family' of the travelling showman is constructed." In the case of these perch, however, the "happy family" theory will hardly serve. The perch's whole attitude is expressive of a desire to catch the minnow, a task which has come, however, to be regarded as hopeless. Such an explanation is also made less plausible by the fact that different minnows of different size were tried in the course of the experiment. And, indeed, habituation by constant association is hardly to be considered here; for the minnow, at least in the first series of experiments, was exposed to the sight of the perch but a short time each day, and at the period of greatest hunger, which furnishes in itself the strongest possible stimulus, not to the production of feelings of friendliness, but to the calling forth of savage instincts. That they were acting under the suggestion of their previous failures seems, in the light of the facts observed, the most reasonable explanation. The following incident is confirmatory of this. Toward the close of the work, when the perch had ceased to bump the glass in their efforts to reach the minnows, some angleworms were thrown into the tank on the side of the partition opposite the perch and lay squirming on the floor. The fish dashed violently against the partition in their effort to reach them, and beat the glass energetically for some time.

Their behavior in the presence of a strong suggestion, counter to their newly acquired habit, also militates against the view offered by Bateson. About the end of the third week,

while attempting to remove one of the minnows from the aquarium, it slipped through a crevice at one end of the partition into the part occupied by the perch, and dashing directly toward them in its flight was snapped up like a flash. The rapidity of its movement was probably the prime incentive, and called out the normal tendency to strike, before the later acquired inhibition could come into action. This minnow, or its mate, had gained entrance to the perch in the same way a few days previously, but in this case in a less exciting manner. The perch, aside from the female's nudging its tail twice, paid no attention to it, although it swam around them and under their very noses.

The restraining influence under which they were acting was again broken a few days later. Circumstances made necessary the omission of the test till two days after the regular period had passed. They were therefore wild with hunger and the opportunity for observing a conflict of impulses was of the best. The minnow was admitted, and at first was treated much as on other occasions. After a few moments, however, being evidently impelled by hunger, the perch became more demonstrative toward it, but restrained themselves from striking, so long as it quietly avoided them. Finally, however, being followed into a corner, it made a quick dart to escape, and this was apparently all that was required to wake the sleeping instinct, and a savage chase began which must have ended fatally to the minnow, had I not separated them. The perch were thoroughly aroused and all effect of their training seemed, for the time being, to be lost. A few more bumps at the glass during succeeding trials, however, restored the inhibition,and the final test made a little later showed it to be quite firmly impressed upon them. The minnows were removed from the sight of the perch for five days. To ascertain whether any effect of the training yet remained, they were then put directly into the compartment with the perch which had eaten nothing for two days. It was plain to the observers that the behavior of the latter had been greatly modified by the course of education to which they had been subjected. The first minnow put in soon attracted their attention. Their interest increased as they followed it about, and the female began to strike at it with growing boldness, and getting it into a corner finally secured it. The second minnow was greatly desired by the male, but he seemed utterly inefficient. He would trail it around and at times make feeble darts at it and then give up the attempt for the moment. In this way he was seen to nag it for nearly an hour. On returning to the tank after five hours the minnow was found swimming near the perch entirely unmolested. The male's experience had apparently so far inhibited his natural

reaction that he had ceased to try. As Paulsen remarks of the pike in Möbius's experiment, "he had manifestly made a law of nature for himself." A strike at the minnow had come to mean a bump on the nose for him.

In regard also to the general educability of fishes my observations are at variance with those of Bateson. He says with regard to the persistence with which the fish in the tanks of the Marine Biological Associon beat the glass, and their slowness to profit by experience or to form associations: "None of the fish seem to get any lasting appreciation of the nature of the plate glass wall of the tank. The same fish will again and again knock the head against the glass in trying to seize objects moving on the other side. After repeated attempts to take food on the other side of the glass they will desist, but some of the oldest inhabitants (plaice, pollock and bream) which have been living in the aquarium for about a year, will perseveringly try again the next time." This was not the case with the perch under discussion. While these fish did not entirely cease striking the glass during the time when the trials were but thirty minutes long, their attempts grew very much more infrequent and their blows feebler. Later in the changed form of the experiment, becoming accustomed to the sight of the minnows, they gave up striking the glass, merely continuing to watch them. This, in connection with their conduct toward the minnows when the glass was removed, suggests that they have at least a strong temporary appreciation of the obstacle.

Another proof that they had formed a firm association with regard to it may be taken from the notes. On April 21st the partition which had been in position for several days was removed and the perch driven toward the place previously occupied by it. On reaching it they stopped and turned back. "On May 4th, glass removed in order to clean tank, but waited to see if fish would cross the line. The male swam out to the place, stopped, made little bumps forward as if expecting to strike the usual obstruction, and was plainly at a loss. He then turned and swam down as if following the glass." Ten days later with the same conditions they swam out to the mark several times, then turned and swam back. So on a later occasion when the glass was taken out they turned three times at the mark, but finally crossed in a hesitating manner.

During the period in which they had lived on minnows the perch remained indifferent to man, but when their diet was changed to angleworms they began to take such a deep interest in the experimenter that it was necessary to use a screen in the trials. This added considerable interest to the study, especially as regards their memory and time sense. After releasing the minnows the experimenter took his place behind the

screen, viewing the movements of the fish through a narrow slit, and they saw nothing of him for thirty minutes. During this period, however, he was not forgotten. The first half of the time was pretty fairly divided between the minnow and the screen. As shown by my notes a marked change took place in the last half of the half hour period. They spent a larger and larger portion of the time gazing out toward the screen. Circling the tank rapidly a few times with growing excitement they would return to the spot, snapping their jaws and flirting their tails, till toward the close of the period they had attention for little else than the appearance of the man behind the screen. The time sense here exhibited is probably in large part a feeding-time sense; they remembered with their stomachs. The rhythmic recurrence of internal sensations due to a regular feeding time may well account for the form of memory here involved.

The same hunger memory might possibly help to explain the stories of fish coming regularly at the sound of a bell to be fed. Bateson found, in the study before referred to, that most fish hear little or nothing of sounds in the air, but are affected by vibrations of the water and earth near it. The subject has also been carefully studied by Kreidl[1] and by Lee,[2] whose experiments are in agreement with his. Lee thus summarizes the case as presented in Kreidl's second paper: "Kreidl explodes the oft repeated tale of hearing by fishes that come for their food at the sound of a bell, by investigating carefully the action of trout at the famous old Benedictine monastery in Krems, Austria. He proved that the fishes come because they see the man who brings the food, and appreciate the vibrations of the water caused by his step and communicated through the stone basin; and that, when these are excluded, the sounds of the bell have no effect." The weight of recent authorities is thus against the existence in fishes of an auditory sense in the usual meaning of the term. My own observations, though not of a character to support an opposite conclusion, seem to me to require for their explanation the existence of a "sense of jar" of a delicacy at least equal to that of hearing. I made it a practice to whistle loudly while feeding the fish, and often while behind the screen I would use the whistle in the same manner. Very often at such times they would come directly to the side and look eagerly at the screen. Often they would turn only slightly in my direction; and in a very few cases they paid little

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[1] Kreidl: Ueber die Perception der Schallwellen bei den Fischen, *Pflüger's Archiv für Physiologie*, Bd. LXI, p. 450, also Bb. LXIII, p. 581.

[2] Lee: The Functions of the Ear and the Lateral Line in Fishes, *American Journal of Physiology*, I, 1898, 128-144.

or no attention. Some gold fish in the laboratory, however, hardly ever failed to come at the sound of the whistle, especially if hungry. In regard to the fish feeding stories, it must be agreed, however, that the sight of the man ringing the bell is the chief factor.

Belonging to the group of fishes that find their food by sight, the perch possess great keenness of vision. They are so highly reflex, also, that the least visual perception of motion puts them into action. Two bright buttons kept in oscillation by the incoming water were a constant source of attraction to them. The swaying objects when caught in indirect vision seemed never to fail of bringing them to attention. Of course the trolling hook, with its revolving spoon of bright metal, depends for its efficiency on this deep seated interest in bright and moving objects.

These fish are very imitative, a movement in one almost surely producing a similar movement in the other. This trait is probably due to their primitive shoal life, where it was necessary to follow the crowd or fall a victim to the host of enemies on the outskirts.

To test their power of discrimination a species of wireworm was dropped into the tank alternately with small angleworms broken to the same length. The difference to sight was very small indeed. On one occasion when five were thus given, the first three were taken into the mouth and then rejected. The remaining two were permitted to sink to the bottom untouched. In subsequent trials the first wireworm has generally been taken into the mouth and the others neglected, the discrimination perhaps being aided by taste or possibly by the sense of touch in the mouth. The fish seemed, however, to make no fully permanent associations, but always to test the possibilities of such an object falling through the water.

STUDIES OF RHYTHM AND METER.

By Norman Triplett and Edmund C. Sanford.
(*From the Psychological Laboratory, Clark University.*)

I—On the stanza forms of nursery rhymes.
II—An experimental study of the rhythms of nursery rhymes.
III—College yells.
IV—A brief collection of common rhythms with words that have been fitted to them.

I. On the Stanza Forms of Nursery Rhymes.

In attempting to recall a forgotten phrase or stanza it is by no means uncommon to recapture the "sound" or "lilt" of it, while the words escape; we recall the form or plan of the phrase, but not the filling in. At other times, as in listening to a conversation indistinctly heard, *e. g.*, by telephone, we are able, from the familiar cadence of the sounds, few of which are distinct enough to be fully recognized, to reconstruct the phrases which we can hardly be said to hear. To such groups of related sounds and others similar, considered merely as sounds, we may give the name of auditory forms.

Auditory forms bear the same relation to the things of the auditory world—phrases of speech, city noises, cries of animals and the like—as the figures of bodies bear to the things of the visual and tactual worlds. An ivy leaf or the new moon is not more characteristic and easily recognizable in its visual form than the crowing of a cock or the hoof-beat of a galloping horse in its auditory form. Visual form means certain fixed associations of visual, tactual and kinæsthetic sensations; auditory form certain fixed associations of auditory and kinæsthetic sensations. In both cases the form pure and simple is the result of a certain degree of abstraction (not necessarily conscious); the color and material of a pebble are neglected when its roundness is considered, and in the same way the words and meaning of a phrase are neglected when its rhythm is regarded. Furthermore, as there are in the visual world objects of the most varied form, some irregular, like clods and rock masses, others with regularity of plan, like flowers and fruits, and finally, objects of human construction showing the regular geometrical figures, so there are in the auditory world forms of considerable irregularity, like those of prose speech, others of approximate regularity, like lines of poetry

and phrases of music, and still others of complete regularity, like the ticking of a clock or the artificially grouped sounds of the laboratory experiments on rhythm,—these last fairly comparable to the geometrical figures—the regular chronometrical figures as they might be called.

It is the purpose of the following studies to present certain observations and experiments with reference to auditory forms of the more regular sorts, and of this section and the next to consider the stanza forms or "metrical patterns" of nursery rhymes.

These rhymes offer a natural approach to the study of poetical rhythm and meter in general. They are in the highest degree rhythmical, almost everything else being sacrificed to that, and they are simple, as they must be to suit the tastes and comprehension of little children. They owe their origin, of course, to the natural responsiveness of children to rhythmic sounds and movements. Some are clearly motion songs. The regular movements used for lulling the child to sleep or those of marching have furnished a framework which has later been given a verbal covering, and rhythmic movements are still a frequent accompaniment of some of them. Others seem to have started in the mere repetition of a single word, as "Peter, Peter," or a common phrase as "There was an old woman," or "There was a little man." The rhythm thus set was carried on as words offered and fancy suggested till a full stanza was formed, crude at first perhaps, but improving with time and as the rhyme passed from mouth to mouth. Still others have had a definite history and have entered nursery literature from popular verse at various times. Many have the irregularity of all natural and spontaneous products, and take liberties in the matter of accent and pronunciation that would hardly be tolerated in more formal verse, yet the difficulties thus introduced are not very serious. For present purposes they may be entirely neglected, for in the more familiar rhymes, at least, they affect the foot structure rather than the stanza forms.

The rhymes that have formed the basis of this study are the one hundred generally familiar ones collected by one of us in answer to a request addressed to a large number of persons for a list of ten rhymes each—if possible the first ten coming to mind.[1]

The most frequent stanza form in this list is that of four lines of four stresses each, for example,

> Georgie, porgie, pudding and pie;
> Kissed the girls and made them cry.
> When the boys came out to play,
> Georgie porgie ran away.

[1] Triplett: A Census of Nursery Rhymes, Journal of Pedagogy, April, 1901.

In nearly all cases the lines rhyme in couplets as in this example, showing the close relation of this stanza pattern to the simpler pattern of the couplet. The couplet is itself not uncommon, either standing alone or repeated as the stanza unit of longer rhymes, as for example,

> Needles and pins, needles and pins!
> When a man marries, his trouble begins.

and

> "Where are you going, my pretty maid?
> "I'm going a milking, sir," she said.
>
> "May I go with you, my pretty maid?"
> "Yes, if you please, kind sir," she said, etc., etc.

The 4-stress line, especially in couplets, is very ancient in English poetry,[1] and is based on what appears to be a very natural grouping for sounds of moderate frequency.[2] The simplest possible rhythmic structure is undoubtedly the grouping of stresses by twos, and of 2-stress lines there are a few examples among the nursery rhymes,—for example,

> One, two;
> Buckle my shoe.
> etc., etc.

The next stage, antedating (one may conjecture) any attempt at a 3-stress line, is the line of two twos, or the 4-stress line. These united in the simplest possible way gives the couplet, the fundamental pattern of this group, and a pair of couplets the most frequent stanza of the nursery rhymes. The stanza of four 4-stress lines, rhyming in couplets or otherwise is also a very common one in lyric poetry generally. In hymnology it occurs as the long meter stanza (iambic) and as the four line stanza of 7's (trochaic), both extremely common hymn stanzas.

Another numerous group is that in which the stanza consists of two 4-stress lines (the first and third) and two 3-stress lines (the second and fourth), or, as it might as properly be written in most cases, of a couplet of 7-stress lines or septinaries.[3] Of these there are two varieties, one in which the 4-stress lines are broken by internal rhyme, and one in which they are not. As an example of the first we may cite

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[1] *Cf.* Schipper: Grundriss der englischen Metrik, Leipzig, 1895, pp. 108, 176.

[2] *Cf.* Bolton: Rhythm, *Amer. Jour. of Psy.*, VI, 1893-95, pp. 212, 216.

[3] No spatial arrangement of the parts of a stanza can give a parallel of the temporal arrangement presented to the ear, unless it be the placing of all the parts in a single line, with spacing to indicate the separation of the parts.

Mistress Mary, quite contrary,
  How does your garden grow?
Silver bells and cockle shells
  And pretty maids all in a row.

Of the second,

There was a man in our town,
  And he was wondrous wise;
He jumped into a bramble bush
  And scratched out both his eyes.

The first is extremely common as a nursery rhyme pattern, but rather rare in adult verse; the second very common in adult verse, but less so among the nursery rhymes. The latter is the stanza of many ballads and hymns (ballad meter, common meter) and very frequent in other kinds of verse. According to Schipper (*op. cit.*, pp. 186, 298), both are, like the 4-stress couplets, very old, having prototypes in late Latin and old French. The internal rhymes of the first variety merely carry further a frequent tendency of 4-stress lines to fall apart into two twos, but the short lines make the rhythmic effect of the stanza quite different from that of the second variety, so different in fact as to justify a separate classification. The stanza pattern would indeed be more fairly represented by printing the rhymed sections of the first variety as separate lines, thus:

  Mistress Mary,
  Quite contrary,
How does your garden grow?
  Silver bells,
  And cockle shells,
And pretty maids all in a row.

If one should attempt to describe the difference in words he might say that the form with internal rhyme gives the effect of two partial, or not wholly successful, efforts, followed by complete success on the third trial, or of two small waves followed by a third large one that runs far up the beach. In the stanza without the internal rhyme the effort is sustained throughout the whole of the 4-stress line and falls in the 3-stress line. The quick recurrence of rhymes in the first variety not only gives the stanza a quick movement and much jingle, but rhymes in such close proximity are themselves very emphatic,[1] and mark the stanza pattern in a striking way, features which would recommend it to the poet of the nursery more than to the poet of adults.

Between these two varieties stand several nursery rhymes which have internal rhymes in the first or third line (most frequently in the first), but not in both. For example,

[1] *Cf.* Corson, Primer of English Verse, p. 23, f.

See, saw, Margery Daw,
  Johnny shall have a new master.
He shall have but a penny a day,
  Because he can't work any faster.

It is the existence of such transition cases and of the cæsural tendency in many 4-stress lines that justifies making one class of such divergent varieties.

After these in frequency comes a third four line stanza, composed of three 3-stress lines (the first, second and fourth) and one 4-stress line (the third). Like the last this form occurs in two varieties, one with internal rhyme in the 4-stress line and one without. For example,

  Hickory, dickory, dock.
  The mouse ran up the clock.
The clock struck one; the mouse ran down.
  Hickory, dickory, dock.

and

Peas porridge hot,
  Peas porridge cold,
Peas porridge in the pot,
  Nine days old.

These correspond in pattern to the short meter stanza of the hymn book, and, when taken as composed of two long lines, an Alexandrine and a septinary, to the "poulter's measure" of the Elizabethan writers. Schipper (*op. cit.*, p. 199) regards it as better suited to comic verse than verse of other sorts, and single stanzas of the variety with internal rhyme (the 4-stress line being printed as two twos) were very common in the humorous columns of the newspapers a few years ago.[1] An interesting feature of the nursery rhymes of this pattern is that in most cases, at least of the more familiar ones, the last line is a repetition of the first, or a close approximation to it. The repetition seems to bring the whole to a close and round it off, like the return to the keynote in a piece of music.

The three groups of stanza patterns so far considered include about four-fifths of the nursery rhymes of the hundred in question, and nearly half the hymns of a hymnal examined for comparison.[2] Of the remaining rhymes some are of regular but infrequent forms (stanzas of 2- and of 3-stress lines, or of three 4-stress lines followed by a 3-stress line), some vary in form from stanza to stanza, and a few defy classification.

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[1] A single example will suffice:

A maiden, named Molly Maguire,
Had trouble in lighting her fire.
  The wood being green,
  She used kerosene;
She has gone where the fuel is drier.

[2] The revised edition of that used in the Episcopal church in this country.

Of the three more common patterns, the first has less definiteness and unity than either of the others, or depends for its unity to a considerable degree upon other than rhythmic conditions. When the four line pattern is composed of couplets, there seems little reason in the rhythm alone why it should not stop at the end of the first couplet, or go on indefinitely, couplet after couplet, as indeed it does in some cases. When the pattern is represented in bare taps (*e. g.*, with a lead pencil on the table) there seems also little reason for stopping after four groups of four taps rather than after two such groups or even after one. The unity of the couplet itself is not great, though in setting over against each other two natural rhythmic units (here two 4-stress groups) it may have a certain degree of completeness, and this may be further strengthened by the ease with which a 4-stress couplet fits into the ebb and flow of respiration, but the presence of rhyming words is important in marking off both the couplet and quatrain of this sort. Upon what other factors their rhythmic importance depends remains to be investigated.

The second pattern has distinctly more unity than the first. The 4-stress line, or the pair of 2-stress lines, with the 3-stress line following forms a whole having a definite auditory configuration, and is recognizable when reproduced in bare taps. Two such wholes constitute the stanza, which thus acquires a unity comparable to that of the couplet.

The third pattern is the most distinct and unitary of all. It comes to a definite close and has no tendency to repetition, except as a whole, a characteristic which perhaps has something to do with its fitness for single stanza humorous verses and its unfitness for general lyric use where all the stanzas must contribute toward the larger unit of the poem. It seems to stand on the same grade of unity as the single 4-stress line of the first group and the half stanzas of the second group. When represented in bare taps, it has a perfectly clear and recognizable character, and has often been used, as will be shown later, where definite and recognizable rhythmic effects are desired.[1]

The essential thing in all these stanza patterns appears to be the stressed syllable, or rather the group of stressed syllables recurring, at equal intervals of time, and marked off, group from group, by pauses or rhymes or both. The syllables which fill up the intervals between the stressed ones, introduce them, or follow them, seem generally to be of less importance. They make one stanza differ from another of the same pattern, but they do not change the pattern. The pattern on the contrary seems to dominate the syllables and, at least in the nursery

[1] *Cf.* Section III below.

rhymes, to force them into accord with itself. Many examples of this are to be found, especially where several syllables are crowded into a single interval, or where a single stressed syllable is extended to fill a whole one. Some of these will be noticed in the experimental section below; here we desire to speak of two or three rhymes in which, with different treatment of the syllables in question, conformity to more than one pattern is possible. In the following rhyme, for example, the first and third lines are a syllable short for the common meter pattern.

Sing a song o' six pence,
  A pocket full of rye;
Four and twenty blackbirds,
  Baked in a pie.

If the last syllable in these lines is unstressed, the stanza pattern becomes one of four 3-stress lines—a rare one among nursery rhymes. If on the contrary the syllable immediately preceding the last is held long enough to bring a stress on the final syllable it conforms to the common meter pattern, and this as a matter of fact appears to be what often happens. The results of tests with children on this point will be given in the next section. Two lines in other stanzas of the same rhyme have the full quota of syllables, though this alone would not be conclusive; for the rhymes do not always adhere to the same pattern throughout. It is probable also that some readers bring the words to a familiar pattern in another way, namely, by taking the rhyme as a tetrameter couplet, which would make it conform to the still more common 4-stress group. Thus,

Síng a song o' síx pence, a pócket full of rýe;

Fóur and twenty bláckbirds, báked in a píe.

In the following rhyme (which, however, did not occur in our hundred) there is an extra syllable in the second and fourth lines, if the rhyme is taken as having the common meter pattern, or a syllable too few if it is taken as having the long meter pattern.

Once in my life I married a wife,
  And where do you think I found her?
On Gretna Green in a silken sheen,
  And I took up a stick to pound her.

She jumped over a barberry bush,
  And I jumped over a timber,
I showed her a gay gold ring,
  And she showed me her finger.

In the first stanza the syllables immediately preceding the last in these lines—"pound" and "found"—are of them-

selves very long, and a little further time is also required if the h in "her" is given distinctly—so that it is easy to make these syllables long enough to bring an extra stress on the following syllable and fit the whole to the pattern of four 4-stress lines. In the second stanza the penultimate syllables of the second and fourth lines are not so long and the tendency to stretch the lines is less strong, and perhaps would not be sufficient to keep the rhyme from falling into the common meter pattern, were it not for the influence of the stanza immediately preceding.[1]

In the similar rhyme beginning "See, saw, Margery Daw," the penultimate syllables of the second and fourth lines are only of moderate length, and the tendency to extend the lines to the 4-stress limit is not very marked. It is probable, however, that even this rhyme is sometimes pressed by children into the pattern of four 4-stress lines. In a musical work entitled "Mother Goose Songs without Words,"[2] in which a skillful musician has tried to catch the rhythm of familiar nursery rhymes as they are repeated by children, both "Sing a song o' six pence" and "See, saw, Margery Daw" are fitted with notes that indicate 4-stress lines. The same is true also of "Bye, Baby Bunting," and "Goosey, goosey, gander." The majority, however, of the group of school children tested with the former of these rhymes, gave it but three stresses per line.

Little need be said about the foot structure of the nursery rhymes, except that they are extremely free, the only requirement seeming to be that the stressed syllables should recur at approximately equal intervals. As a result of this liberty the three syllable feet are freely mixed with the two, and it is rare to find a rhyme that maintains a single type of foot throughout. Some apparent irregularities in the way of extra syllables at the beginning of lines will, however, find their proper place in the rhythm when the rhymes are written in long lines instead of short.

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[1] Brücke in his *Physiologische Grundlagen der neuhochdeutschen Verskunst*, pp. 25 f, finds a similar result with Goethe's *Es war ein König in Thule*. When the recitation of such verses is accompanied by tapping movements of the hand, as in Brücke's experiments and in those to be discussed in the next section, the tendency is very strong to force the rhythm, natural pronunciation of the words being a little strained in order to fit the more uniform movement of the hand. Something similar seems to have been observed by Pringle. *Cf.* Shaw and Wrinch, A Contribution to the Psychology of Time. University of Toronto Studies, No. 2, p. 50.

[2] By Mrs. L. E. Orth, published by The Oliver Ditson Co., Boston, 1897. The composer has endeavored by a series of simple pieces embodying the familiar rhythms of the nursery rhymes to pave the way for children to a comprehension of rhythms as expressed in the ordinary musical notation.

It would be an interesting question, finally, to ask how it happens that the three chief stanza patterns hold the place they do among the nursery rhymes and in serious verse. It is easy to say, and doubtless in large measure true, that they owe their unique position now to their great frequency in the past. We have been trained to them as we have to the ordinary church cadences and the return to the keynote, but the question remains of why they came into frequent use originally, and the answer must probably be looked for outside the data obtainable by a study of the forms themselves.

II. An Experimental Study of the Rhythms of Nursery Rhymes.

Purpose and Method. Our purpose in undertaking an experimental study of these rhymes was one that must have suggested itself to every student of rhythm, namely, to secure, if possible, some objective record of rhythms as they actually occur in spoken verse.

The way in which we finally approached the question, after much preliminary testing, was essentially like one of those used by Brücke, though improved, as we believe, in some particulars.[1] In both methods the rhythm was tapped by the finger

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[1] Brücke: Die physiologischen Grundlagen der neuhochdeutschen Verskunst, Wien, 1871, pp. vii, 86. His methods were at the time unknown to us.

A few words with regard to the methods of Brücke and others may be added here. Brücke made use of two methods, the first for studying the relations of the stressed syllables in the line or stanza, the other for determining the quantities of the syllables in the foot. The first (*op. cit.*, p. 23) consisted in marking each arsis, or each arsis carrying an ictus, with a quill on an evenly revolving kymograph drum, while reciting verse of different kinds. In the second method (p. 32, ff.) the lip movements were recorded during the pronunciation of certain lines specially constructed in syllables involving labial consonants to show characteristic foot structures. The lip movements were traced by means of a thin strip of wood, fast at one end, and resting at the other on the speaker's lip. At a suitable place a writing point was attached for inscribing on the drum surface.

Hurst and McKay (Experiments on the Time Relations of Poetical Meters, University of Toronto Studies, Psychological Series, No. 3, 1899) were, unknown to us, at work at about the same time on a closely related problem and by a similar method, a refinement of Brücke's first method. Their plan was to have the syllables of ten or twenty successive feet of standard selections marked while the subject scanned them silently, or to have series of feet of the standard forms (dactyl, anapest, etc.) tapped off empty, *i. e.*, without words, while attention was concentrated on the rhythm. It is important to note that in using the tapping method for the marking of the constituent elements of the foot instead of the interval from arsis to arsis the work of Hurst and McKay approaches that of Brücke with his second method, while ours is like that by his first method.

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in accompaniment to the voice reciting the lines, but in ours a voice record also was taken by one of the methods used by Rousselot and more recently by Bourdon.[1] For the finger record a small receiving tambour, placed conveniently to hand on the table, received the taps and communicated them to an inscribing tambour which in turn transferred them to the smoked surface of a kymograph drum, each tap being marked by a sharp departure of the pointer from the base line. For the voice record a short tube of large diameter fitted with a suitable mouth-piece led directly into the metal box of a tambour, the stylus of which traced on the drum the impulses communicated to it by the breath of the speaker. For a time line an interrupter giving tenths of a second was used, and the speed of the drum was such as to allow the reading of these by estimation in tenths, making the unit of measurement 0.01 second.

Records were taken during the course of the experiments upon a number of different subjects, but in small number, and only those taken upon the writers will be considered here, except in the case of certain tests made upon school children. Eleven rhymes were studied sufficiently for report. Five of them were of the long meter or other 4-stress patterns, as follows:

Georgie, porgie, pudding and pie,
Kissed the girls and made them cry.
When the boys came out to play,
Georgie, porgie, ran away.

Intery, mintery, cutery, corn,
Apple seed and apple thorn;
Wire, brier, limber, lock;
Three geese in a flock;
Sit and sing by a spring;
O, U, T, and in again.

Diddle, diddle, dumpling, my son John
Went to bed with his stockings on;
One shoe off and one shoe on,
Diddle, diddle, dumpling, my son John.

There was an old woman, and what do you think,

VII, 1899, pp. 95, ff.) has made an exhaustive study by refined methods of the first stanza of "Who Killed Cock Robin?" but as the rhyme was apparently read rather than scanned and is one of the more complicated ones metrically, his study and ours do not overlap to any considerable extent.

These researches are the only ones known to us, if we except the brief account of results given by Meumann, in which the particular matter in hand has been approached in an experimental way. The results reached, so far as they have to do with our own, will be spoken of in the text as occasion arises.

[1] Bourdon: L'Application de la méthod graphique à l'étude de l'intensité de la voix, *L'Année psychologique*, 1897, 369-378.

She lived upon nothing but victuals and drink.
Victuals and drink were the chief of her diet,
And yet this old woman could never keep quiet.

There was an old woman that lived in a shoe;
She had so many children she did n't know what to do.
So she gave them some broth without any bread,
And whipped them all soundly and sent them to bed.

Those of the second, or common meter, class were:

See, saw, Margery Daw;
Johnny shall have a new master.
He shall have but a penny a day,
Because he can't work any faster.

Mistress Mary, quite contrary,
How does your garden grow?
Silver bells and cockle shells,
And pretty maids all in a row.

Old King Cole was a merry old soul,
And a merry old soul was he.
He called for his pipe and he called for his bowl,
And he called for his fiddlers three.

If all the world were apple pie,
And all the sea were ink,
And all the trees were bread and cheese,
What should we do for drink?

Hey! diddle, diddle, the cat and the fiddle;
The cow jumped over the moon.
The little dog laughed to see such sport,
And the dish ran away with the spoon.

The single example of short meter was

Hickory, dickory, dock,
The mouse ran up the clock;
The clock struck one, the mouse ran down.
Hickory, dickory, dock.

Our main dependence in the working up of the combined hand and voice records has been that of the hand. The means employed for recording the voice are imperfect, really furnishing a record of the movements of the breath and not that of the vocal intensities at all. From such a record alone it would therefore be quite impossible to get any picture of the rhythm. The voice record, however, does enable us, at least in the case of the explosive consonants (*p*, *b*, *k*, and *c* and *g* hard) to determine with some exactness how nearly the finger tap agrees with the vocal stress.[1] That the voice and hand should keep in close coincidence was of course to be expected in view of the strong natural tendency to beat time in some

[1] Brücke, *op. cit.*, p. 24, f., and 32.

way or other, but an objective determination of the degree of exactness is not wholly without interest. The relation between the hand and voice has been carefully worked out for both subjects with the rhyme "Georgie, porgie," which is rich in these consonants. In few cases does the average difference between the hand and voice (average of ten trials) exceed 0.02 sec. Once in the case of S with the word "boys," the difference reaches 0.049, but this is so much larger than the rest that an error is probable either in locating the point of the voice curve corresponding to the beginning of the *b* or in supposing that in the enunciation of this subject the stress in this syllable falls close to the consonant and not later in the diphthong following. The other cases all lie below 0.03. In the record of S for "Mistress Mary" the same relations are true, except for the first syllable of "pretty" where the average difference is 0.022, and for "bells" where it is 0.031. When the mean variations are examined it is found that in "Georgie, porgie" they exceed 0.02 in two cases, once for each subject, the highest being 0.03 sec. In "Mistress Mary" for S there are also two instances the highest being 0.026. The differences of hand and voice are larger than could be wished, yet, even if we take the extreme cases (excluding only that of S with the word "boys") we find that they rarely exceed the limit laid down by Meumann (0.02);[1] and if we take in the same way the largest mean variations, we find that none correspond to a probable error in the averages of ten of more than 0.01 sec. There would, therefore, appear to be sufficient justification for taking the finger record, within the limits indicated, as synchronous with the vocal stress.

It should not be inferred that the tapping introduced a distraction into the recitation of the rhymes, for this was not the case. From the first the tapping was practically automatic, and no difficulty at all was found in doing both at once. The effect of the tapping, as has been intimated in the preceding section, was probably of quite another sort, tending to enforce by its own regularity, a greater steadiness on the recitation than would usually be expected in vocal utterance. In the case of genuine poetry this would certainly be a serious, and, we believe, a fatal, objection to the method, but in the case of the nursery rhymes, where the usual recitation often approaches scanning, the greater regularity, if introduced, would seem to be a secondary matter. Nevertheless the fact should not be neglected in inferences based upon the results to be given. In taking the records the rhymes were recited in the

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[1] Untersuchungen zur Psychologie und Æsthetik des Rhythmus, Wundt's Studien, X, 1894, p. 419.

child's fashion, making the rhythm prominent, nearly to the full extent of scanning.

General Rate of Recitation. A question that naturally arises in discussions of rhythm is whether or not there is anything like a fixed individual rhythm to which the reading of each subject tends to conform itself. The answer which our experiments give to this question is partly affirmative and partly negative. The subject S read more rapidly than T with nine out of the eleven rhymes used, and often by a very considerable amount, and other experiments have shown a similar tendency in his reading of other sorts of verse. There would thus appear to be a certain relative constancy of type—quick, moderate or slow—in the rate selected, but not one by any means that excludes differences, *e. g.*, between repetitions of the same rhyme on different occasions, especially with different mental conditions, between different rhymes of the same metrical pattern, or between rhymes of different pattern. This will be clear from the following table in which are given the average foot or more exactly the average interval between arsis and arsis for the different rhymes studied. In calculating this all partial feet and all feet affected by the regular rhythmic pauses have been excluded.[1]

TABLE I.

Showing in seconds the average interval between stresses.

LONG METER PATTERN.	S.	T.
Georgie, porgie,	0.458	0.516
Intery, mintery,	0.548	0.566
Diddle, diddle, dumpling,	0.471	0.527
There was an old woman, and what do you think?	0.476	0.568
There was an old woman that lived in a shoe,	0.652	0.620
COMMON METER PATTERN.		
Mistress Mary,	0.503	0.562
Old King Cole,	0.522	0.616[2]
Hey! diddle, diddle,	0.322[3]	0.458[4]
See, saw, Margery Daw,	0.548	0.533
If all the world were apple pie,	5.406	0.484
SHORT METER PATTERN.		
Hickory, dickory, dock,	0.361	0.452

[1] The averages are given in this case without the mean variations, which would have required an amount of extra figuring quite disproportionate to the additional value afforded by them. Their size can be judged with sufficient exactness from those given in Table II, where the intervals are presented in percentages with their corresponding mean variations.

[2] Average of 9 repetitions.

[3] Average of 7 repetitions.

[4] Average of 8 repetitions.

has seemed better to give the foot lengths (intervals between stresses as marked by the finger taps) in percentages of the total time required for reciting the rhyme, instead of in the time values obtained directly from the kymograph sheets.[1] These percentages with their corresponding mean variations are given in the several parts of Table II inserted at the end of this section. Each figure is the average of ten percentage records (except where the contrary is specified) calculated from the original time values. The average recitation time in seconds is given for each rhyme immediately following the initial of the subject, and from this the actual time of any interval can be calculated approximately should any one desire to do so. To these have been added a few records of tappings of the three standard patterns without recitation of any rhymes whatever, simply as pure metrical patterns. Little importance was attached to these when they were taken, and they are therefore very few in number, but they are so consistent with themselves and have proved so interesting in connection with the records of the rhymes that it has seemed worth while to publish them. These records are given complete in units of 0.01 sec.

In discussing this table we shall consider first those general features which throw light upon the recitation of all the rhymes, then those that have to do with the different stanza patterns and individual rhymes, and finally such indications as appear with reference to the rate of recitation of feet of various forms.

It will be noticed that there is a rough equality in the figures

[1] The "total time" referred to in the text was measured from the beginning of the first finger tap to the end of the voice record, except in the case of the rhyme "Mistress Mary" with subject S, where the end of the voice record could not be determined with sufficient accuracy, and the time used was that between the first and last finger taps. The record does not include the time of introductory syllables such as occur in three of the rhymes, which were not easy to measure with certainty by the method employed. In the case of these rhymes the record is therefore incomplete, though not to a degree to invalidate it in any way for the purposes to which we shall apply it. The part of the voice record following the last finger tap was secured by having the subject take breath instantly after the enunciation of the last syllable while his mouth was still in contact with the mouthpiece. This introduced a sharp and unmistakable fall in the voice tracing which was taken as marking the end of the recitation. The determinations thus obtained are a little too large, but probably by an insignificant amount—less we believe than the usual reaction time. The criticism may possibly be offered that the effort to mark the end of the rhyme in this way may have led to a slight quickening of the last foot or two. We regret that we cannot present furnish absolutely conclusive evidence to the contrary, but as the taking of the breath at that point soon became automatic, we are not inclined to think that the length of the adjacent intervals was seriously affected by this cause.

for the intervals except where they are lengthened by pauses, as in the seventh interval of the common meter pattern and in the third and sixth of the short meter pattern, or where the figure stands for a terminal syllable, as is the case with the last figure given for each rhyme. This is in accord with Brücke's generalization (*op. cit.*, pp. 23, f.) and the results of Hurst and McKay (*op. cit.*, p. 66), but it is also clear that the uniformity is only an approximate one, and subject to considerable variations. One of the most striking of these is a progressive quickening in rate from first to last of the recitation. This occurred with S in all of the rhymes, and with T in all but two, as appears in the following table in which are set over against each other the average percentages for complete intervals in the first and second halves of the rhymes.

TABLE III.

Showing average percentages for complete intervals in the first and second halves of the rhymes.

RHYMES.	SUBJECTS.	FIRST HALF.	SECOND HALF
Georgie, porgie,	S	6.57	6.19
	T	6.63	6.25
Intery, mintery,	S	4.29	4.18
	T	4.25	4.15
Diddle, diddle, dumpling,	S	6.44	6.23
	T	6.50	6.37
There was an old woman, and what	S	6.39	6.19
do you think?	T	6.57	6.23
There was an old woman that lived	S	6.67	6.23
in a shoe,	T	6.54	6.23
Mistress Mary,	S	7.38	7.07
	T	7.10	7.00
Old King Cole,	S	6.95	6.75
	T	7.38	7.07
Hey! diddle, diddle,	S	6.78	6.75
	T	6.95	7.15
See, saw, Margery Daw,	S	7.11	6.30
	T	7.10	6.53
If all the world were apple pie,	S	6.78	6.51
	T	6.95	6.85
Hickory, dickory, dock,	S	7.30	6.84
	T	7.68	7.86

The only rhymes for which this relation does not hold are "Hey! diddle, diddle," and "Hickory, dickory, dock," where it fails for T. A portion of this difference comes in some cases from an unusual length in the initial interval and an unusual brevity in the last, but the whole tendency is not to be explained in this way. The progressive decrease in time appears even when the rhymes are taken line by line. The averages of the feet

in the successive lines of the rhymes of the 4-stress group are given in Table IV. The facts revealed by them are also true of those of the other patterns.

TABLE IV.

Showing average percentages for complete intervals in the successive lines of rhymes of the 4-stress group.

RHYMES	Subjects	1st Line	2nd Line	3rd Line	4th Line	5th Line	6th Line
Georgie, porgie,	S	6.83	6.30	6.10	6.10	—	—
	T	6.90	6.37	6.43	6.07		
Intery, mintery,	S	4.33	4.13	4.23	4.17	4.23	4.00
	T	4.30	4.10	4.23	4.07	4.27	4.03
Diddle, diddle, dumpling,	S	6.53	6.23	6.26	6.06	—	—
	T	6.70	6.26	6.53	6.23		
There was an old woman, and what do you think?	S	6.60	6.20	6.16	6.23	—	—
	T	6.86	6.40	6.36	6.20		
There was an old woman that lived in a shoe,	S	6.96	6.33	6.36	6.10	—	—
	T	6.70	6.50	6.30	6.13		

Reasons for either the general acceleration or the long initial and short terminal intervals are not very obvious. A variety of more or less plausible conjectures offer themselves. There is possibly a certain amount of inertia in both hand and vocal apparatus at the start, which gives place, as the tapping and recitation progress, to an increasing facility of action due to "warming up" or a local practice, or to the mild excitement of making the experiment.[1] Relatively careful beginnings with rapid and careless endings are not uncommon elsewhere. Observation of a person reading prose aloud will reveal a similar tendency. While the idea is rising into consciousness the words are pronounced slowly and with em-

[1] For the effect of moderate excitement on tapping rates see Dresslar, Some Influences which Affect the Rapidity of Voluntary Movement, *American Journal of Psychology*, IV, 1891-92, p. 523; also Nichols, The Psychology of Time, *Ibid.*, p. 83.

One of the writers believes that the greatest cause of change probably lies in the relation to consciousness of the words in which the rhyme is clothed. The apperceptive effort is high, and the reading rate slow, at the beginning of the stanza and of each phrase, but the effort declines, and a corresponding increase of the reading rate occurs, when the main work of comprehension is for the moment over. This would be but another instance of the general law of economy in accordance with which all our activities tend to be performed with the least possible expenditure of nervous energy.

phasis; having reached the focal point of the idea, however, the remainder of the sentence is hurried out of the way in a more or less indiscriminative mumble. Closely connected with this, doubtless, is the prominence which, according to the rhetoricians, belongs to the first part of a sentence or phrase, for slowness is a normal mark of emphasis. In rapid writing, also, sufficient words of a sentence to carry the meaning are written legibly, the rest less perfectly. A long word may end in a straight line, the writer trusting to the opening syllable and the context to make the thought understood. That the causes are general rather than special is probable from the fact that the same relations hold in some cases, at least, when the patterns in question are executed in bare taps (*cf.* Table II, Pt. v, on the last of the inserted sheets at the end of this section), and similar tendencies have been found even in uniform tapping under certain conditions by experimenters upon time judgments who have made use of the tapping method.[1]

If Table II is examined with reference to the stanza patterns, it will be found that certain of the intervals show characteristic differences. The most striking of these are those which mark off the half stanzas in the common meter pattern and the first two 3-stress lines in the short meter pattern. These are more marked in the case of S, but appear in the records of both subjects, even when the patterns are given in bare taps. In the common meter pattern the interval is often nearly or quite double that of the ordinary intervals. In the short meter pattern its excess ranges from about one-seventh to more than two-thirds of the intervals on either side. The interval in these cases is taken up partly with the completion of the enunciation of the stressed syllable immediately preceding (what proportion can be roughly estimated from that of the last syllable of the rhyme), by a pause, and by the introductory syllable of the following stress when there is one. Such pauses are often used also for taking breath. In the long meter pattern there is also a tendency to mark the line groups by lengthening the interval between the final stress of one line and the initial stress of the succeeding one, but by no means so pronounced. If the general average for this group is consulted (Table II, Pt. i), it will be found that S invariably lengthens these intervals (and also shortens the first interval of the new line). The amounts in question are very small, but the relation can be traced in most of the averages for the single rhymes of the group and is clear in the records of the bare tapping (*cf.* Pt. v). The same relation appears in T's record with bare taps and in some of the averages

[1] Nichols, *op. cit.*, p. 82.

for the single rhymes, but does not appear in the general average and fails distinctly in some of the single rhyme averages. In some cases, however, it may possibly be hidden or neutralized by T's tendency to lengthen the first interval of the line.

The smaller rhythmic periods—couplets and lines—are not further divided by measurable lengthening of special intervals (except as already noticed in the case of the first two 3-stress lines of the short meter pattern), not even in the case of 4-stress lines with internal rhyme. In the bare tap rhythms, however, there are traces of such a method of demarcation (*cf.* Pt. v).[1] The general tendency to increase of rate within the subordinate groups is, however, not without an influence. It gives to the 3-stress lines in the common meter pattern a quicker movement than the 4-stress lines, and may thus be partially responsible for the "falling" character which they seem to have. The subjects differ so much in their rates for the second half of the short meter pattern that conclusions cannot be drawn from the table as to its movement.

It remains to speak of the size of the intervals in relation to foot structure, in other words to the nature of their syllable contents. In the rhymes used there is a considerable variety in this respect, ranging from intervals containing but a single syllable, as in the first two of "See, saw, Margery Daw," to those containing four as in the fifth and seventh of "There was an old woman that lived in a shoe" or the first of "Diddle, diddle, dumpling." Yet few differences are apparent in the figures that can be referred directly to this cause, a result to be expected, perhaps, in view of the prominence given to the rhythm in reciting. It cannot be doubted that when adult verse is read for its meaning as well as metrical structure, very material differences in intervals are to be found. There is reason, indeed, to think that the overfull intervals in "There was an old woman that lived in a shoe" break into the regular movement of the pattern as the rhyme is ordinarily recited by children, though, as will presently be shown, they can bring it into complete uniformity when necessary.

Three of the rhymes—the two about the old women and "If all the world were apple pie," are in iambic-anapestic movement—the last in perfect iambs throughout. The remaining eight are trochaic-dactylic. It does not appear, so far as our results go, that these differences affect the length of the

[1] Such a difference between the verse rhythm and that of bare taps is not unexpected, for the tapped rhythms, having to depend chiefly upon quantity, are at a disadvantage compared with those in vocal form which have at their disposal rhyme, pitch and intensity in addition.

intervals or the general rate of recitation in any uniform way. It is not so much in the general rate of the line as at the beginning and end, where the presence or absence of an extra syllable makes the difference between an abrupt or a gradual beginning, or ending, or sets the character of the movement for the whole that these prosodic differences are effective; though there may also be a difference of movement within the interval, if Hurst and McKay are correct in their measurements of the short syllables in the theses of dactylic and anapestic feet. These authors report characteristic differences in rate for the different feet and conclude that "the dactylic foot tends to be shorter than the anapestic and the trochaic than the iambic" (*op. cit.*, p. 66, f.). This, however, runs counter to common observation, at least with reference to the anapest,[1] and does not hold in our experiments on the rhymes. In Table I, for example, it appears that the pure iambic rhyme "If all the world were apple pie" has a shorter average foot than "Georgie, porgie," which is almost exclusively trochaic. The same table also shows that rhymes containing the same sorts of feet may differ very widely in their rates of recitation. We cannot but think that these authors have been led into error in this particular. A very large number of experiments would be necessary to establish such a difference as they describe; for even the difference between dactyls and trochees and between anapests and iambs disappears when they occur in the same line and the line is scanned.

Observations on the Rhythm of Nursery Rhymes as Recited and Tapped by Children. As a supplement to the experiments above reported, and particularly as a test of the manner in which some of the rhymes which do not quite fit the ordinary patterns would be handled by the children themselves, one of us undertook the observation of a number of young children in one of the public schools of the city.[2] Over forty children of an average age of ten years were tested in all. They were taken singly and, without any suggestion, required to recite several of the rhymes, tapping the rhythm at the same time with the finger. As they are accustomed to do something similar in the counting-out rhymes and in music, they found no difficulty in doing so. The results may be summarized as follows:

Of fifteen children asked to tap the rhythm in "Bye Baby

[1] Coleridge, for example, in the familiar poem in which he illustrates the common forms of feet characterizes them particularly as "the swift anapests."

[2] It is a pleasure to acknowledge here our indebtedness to the Worcester school authorities and to Miss Ella L. Dwyer, the principal of the Oxford St. School, for the opportunity of testing these children.

Bunting" four gave four accents to the line, ten beat it in three and one in two beats. "Diddle, diddle, dumpling" was given in the common meter pattern by nine out of sixteen children. Seven others gave it differently, chiefly in three stress lines, all or nearly all failing to take the somewhat more difficult adaptation to the long meter pattern that we ourselves used in the measurements above reported. Forty-four children recited the familiar rhyme, "Sing a song o' six pence." Of these twenty-seven gave four stresses to the first and third lines, four gave them three stresses, and thirteen two stresses. It was found that the children were satisfied with any of these simple rhythms, and if asked to change did so readily. The fourth line of "Mistress Mary"—"And pretty maids all in a row"—which contains the long syllable "maids" where a short one would be expected, was given in regular time by nineteen children and irregularly by nine. There seemed to be little difficulty where the rhyme was well known. In "There was an old woman that lived in a shoe" the line "She had so many children she did n't know what to do," which contains two feet with supernumerary syllables was taken rhythmically by thirty-three and irregularly by seven children.

A further test was made by placing before each child in his turn a card on which was written

1	2	3	4	5
I	caught	a	hare	alive
6	7	8	9	10
I	let	it	go	again

and requesting him after reading it to himself to read it aloud. Two-thirds of the children read the numerals rhythmically, putting the stress on the 1, 3 and 5 of the first line and 6, 8 and 10 of the third, and in nearly all cases strengthened the accent on repetition.

These tests give evidence both of the facility with which children reduce recalcitrant lines to conformity with the rhythmical patterns and of a freedom in the selection of patterns in doubtful cases. How far the cases in which the rhymes were recited irregularly show habits of repeating them in that way cannot be said, but it is not unlikely that some rhymes are never forced into perfect rhythm by a considerable number of children. These satisfy themselves with the regularly rhythmed portions and get over the irregular portions in the easiest way they can. A more extended study of the rhymes as recited by children when saying them with perfect freedom, without the constraint of tapping or the presence of an unfamiliar observer, would be an interesting and important contribution to the subject.

The general results of this section of our studies may be summarized as follows:

1. We find, with previous investigators, a general uniformity in the intervals between stresses (except when they contain the pauses that mark off the larger rhythmic periods), but also that there is, in the rhymes as a whole and in the rhythmic periods within them, a tendency to a quickening in rate from first to last.

2. The characteristic movement of the most frequent patterns depends partly on the distribution of pauses and partly perhaps on this tendency to increase of rate.

3. The tests on school children show a general tendency on their part to force imperfectly worded rhymes into conformity with one or the other of the more common patterns, but also a certain freedom as to the pattern selected.

III. College Yells.

Perhaps in no field is the phenomenon of rhythm—pure rhythmic noise—more strikingly displayed than in the yells and cheers of college students. From the list published in the *World Almanac* for 1895 and various other sources a collection of fully two hundred college yells has been made, and these have been examined with reference to metrical pattern. While it is not possible in every case to tell from the printed text in just what rhythmic form the cheers are actually given, several points of considerable interest are apparent. The same metrical patterns are found as in the nursery rhymes, but in strikingly different proportions. Yells based on any of the pure 4-stress patterns or on the common meter pattern are infrequent, while yells conforming exactly to the short meter pattern are extremely common, forming as much as a quarter of the whole list, without including many imperfect examples. Several of the yells of the 4-stress group appear to follow the couplet pattern, others the pattern of three 4-stress lines followed by a more or less perfect 3-stress line, and few, if any, that of the long meter stanza.[1] Among the yells were also found several examples of a metrical pattern not represented at all in our list of nursery rhymes, though not wholly unknown to children. It consists of a two followed by a three. Here is an example: Rah, Rah! Rah, Rah, Rah! Rah, Rah! Rah, Rah, Rah! Swarthmore. This is evidently based on the drill sergeant's Left, Left! Left, Right, Left! In the political cam-

[1] One of the writers of this study is inclined to regard some of the cases here classed as 4-stress yells as really 2-stress yells. From the data at hand it is perhaps impossible to say whether the two 2's constituting the four are to be regarded as subordinate groupings or not.

Givi... lative values of the intervals expressed as average percentages

	Av... t...	...ne	out to	play,	Georgie,	porgie,	ran a-	way.
S.	7		6.5	6.7	6.4	6.3	5.6	4.5
M. V.			.27	.37	.32	.29	.23	.29
T.	8		6.4	6.3	6.3	6.2	5.7	3.8
M. V.			.25	.24	.22	.23	.23	.25
		]	one shoe	on,	Diddle, diddle	dumpling,	my son	John.
S.	7		6.1	6.6	5.7	6.4	6.1	4.8
M. V.			.30	.24	.26	.34	.16	.42
T.	8		6.5	6.3	6.2	6.4	6.1	4.3
M. V.			.36	.24	.20	.23	.27	.34
	T	the	chief of her	diet and	Yet this old	woman could	never keep	quiet.
S.	7.		6.1	6.1	6.3	6.3	6.1	4.7
M. V.			.27	.33	.25	.29	.36	.31
T.	8.		6.5	5.9	6.4	6.2	6.0	4.1
M. V.			.21	.23	.23	.30	.33	.43
	T	h-	out any	bread, and	whipped them all	soundly and	sent them to	bed.
S.	10.		6.1	6.1	6.3	6.4	5.6	2.8
M. V.			.16	.22	.35	.21	.24	.25
T.	9.		6.1	6.3	6.5	5.9	6.0	3.2
M. V.			.36	.12	.26	.31	.34	.22
Averages o... percentag... ues of the i... vals.			6.20 6.38	6.38 6.20	6.18 6.35	6.35 6.18	5.85 5.95	4.20 3.85

Charles Ledyard Norton: Political Americanisms, p. 120.

paign of 1884 this pattern was used with the words "Blaine, Blaine, James G. Blaine" and a stamping accompaniment, an idea which Charles Ledyard Norton[1] says can be traced back to the Columbia College students. The same pattern has been observed in use by children as a march rhythm: January, February, March, March, March. The most striking difference, however, is the greater prominence of patterns involving 3-stress groups. These occur of course as constituent parts of both yells and nursery rhymes in the common and short meter patterns, but also among the yells in about eight out of nine of the remaining cases.

These college yells are the settled choice of the students of the various institutions to which they pertain, and in many cases are decided upon by vote of the student body. The proportions found may therefore be correctly considered as the rhythmic preferences of American college students for the purpose for which they are used. It is difficult to state the causes inspiring this choice. It is not to be taken for granted that the preferences of college men for rhythms will be in exact proportion to the size of the groups in such a list of favorite nursery rhymes as that considered in the previous section. Aside from other influences, it is quite possible that the impression left by the rhymes in the short meter pattern may be more lasting than that left by the larger groups of other sorts. A motion rhythm like that of "Peas porridge hot," which all children like to play, would probably have considerable advantage in this respect. It is more probable, however, that the fact noted indicates that some rhythms are better suited for certain purposes than for others, and that the choice of the tripodic form so prominent in the yells rests upon other and perhaps physiological reasons. Three explosive sounds can be uttered with more ease and satisfaction—for respiratory reasons probably—than a greater number (it is a common saying of those who invent yells that the test of excellence is to try them), and with more telling effect than a less number. In cheering, also, the abruptness of the sound is an important factor. A yell without marked pauses cannot possibly be so effective as one in which the pulses of sound are more sharply marked off from one another. An example will perhaps make this clear. The following yell, even when given by practiced voices, merges into a mere bellow of sound: Gloriana, Frangipanna, Indiana! Kazoo, Kazah! Kazoo, Kazah! Hoop Lah! Hoop Lah! State University, Rah! Rah! Rah! One of the more effective type in use in the University of California is—Rah, Rah, Rah, Califor-ni-a, U. C. Berk'lee, Zip, Boom, Ah! In so far as the first lacks in ex-

[1] Charles Ledyard Norton: Political Americanisms, p. 120.

plosive abruptness of rhythm, it loses in stirring effect. The abruptness will of course depend largely on the syllables that compose the yell, but, as appears from the tables given in the preceding section, the short meter pattern has an advantage over the others in having unmistakable pauses at the ends of the first two of its 3-stress lines.

It would be interesting if it were possible to trace the history of cheering. Antedating all college yells, so-called, we have the conventional form of it, which is known as "giving three cheers" or giving "three times three" for a person. This custom was observed at least as far back as the last century, and probably much earlier.[1] It is undoubtedly from this that the original nine rah yells of Yale and Harvard are derived. The question of, why *three* cheers is left unsettled by us with only a conjecture that long ages of practical experience developed this rhythmic form of sounds as the most satisfying and effective.

IV. Some Common Rhythms and the Words that have been Fitted to them.

The tendency of imaginative hearers to give a meaning and a verbal clothing to rhythmic sounds of any sort is everywhere in evidence, especially where there is the perception of conformity of the rhythm to one of the familiar metric patterns. Every one can recall instances. The telephone call of a veterinary surgeon is translated by another person on the same circuit into the perfect iambic line "my horse is sick; come quick, come quick." The rising bell in a large woman's college says to one "crawl out, crawl out, crawl out," and for meals "come in, come in, come in." To another it says "get up, get up, get up," and "quick quick, quick quick, quick quick," respectively. One person was told as a child that the schoolbell said "Helen, come to school," and has heard those words ever since when it rings. The dinner bell is reported by a masculine observer to say, "you hungry cusses, come in, come in; you hungry cusses, come in, come in."

Perhaps the most familiar instance is the interpretation of the ringing of church bells—a very different interpretation, however, in the case of the faithful churchgoer and in that given by the profane sluggard whose rest is thereby disturbed. This general trait has been elaborately worked out in a poem formerly much affected by elocutionists, beginning:

"How sweet the chime of Sabbath bells,
Each one its creed in music tells."

[1] Scots Magazine, in 1789, p. 356.

Each creed in successive stanzas receives its characterization in the language of the bell. Perhaps two instances will suffice:

> "Farewell, farewell, base world farewell,
> Say to the world farewell, farewell,
> Pealed forth the Presbyterian bell."

> "In after life there is no hell,
> No hell, no hell, no hell, no hell,
> Rang out the Universalist bell."

The railroad and steamer furnish an almost inexhaustible supply of meters and rhythms. Engineers of imaginative temperament listening to the voices of their engines endow them with the attributes of a distinct personality, and the traveller by steamer may hear in the throb of the screw: "Got yer trunk, got yer trunk, got yer trunk." Musicians find in such sounds suggestions for motifs as Leonardo found those for pictures in the mottled surfaces of tables. Berlioz is said to have derived the motive for the "Ride to Hell" in the "Damnation of Faust" from the clattering of an express train during a sleepless night. What shall be the meaning given to these rhythms depends on the emotional tone of the hearer. To one young romancer it is the machine spirit repeating with variations the words "Oh hurry up, oh hurry up, oh hurry up." To one who has been bereaved by its agency it is the threatening voice of a cruel monster. Kipling's ".007" covers "his one hundred and fifty-six miles in two hundred and twenty-one minutes"—"a hundred feet to each word."

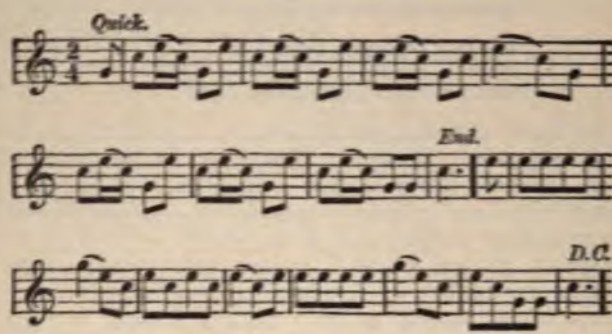
> "With a michnai—ghignai—shtingal! Yah! Yah! Yah!
> Ein—zwei—drei—mutter! Yah! Yah! Yah!
> She climb upon der shteeple
> Und she frighten all the people
> Singin' michnai—ghignai—shtingal! Yah, Yah."

To one listener the ticking of an alarm clock calls up the Lady of the Lake. The patter of rain, the crunching of frozen snow, and even the rhythm of ordinary walking bring a verbal accompaniment to the minds of some. This tendency has long been exploited by the humorist in the croaking of bullfrogs and the hooting of owls. Bird lovers interpret the notes of their favorites. The robin says "Cheer up, cheer up," the white-throated sparrow "See me! Peabody, peabody, peabody." The crowing of the cock to one means "Who the devil cares." To spur his flagging energy a farmer's boy was told that the meadow lark sings "Laziness will kill you," and has continued to hear these words in its song. To others they mean "My poor children."

The various metric patterns presented in the military bugle calls have furnished the best illustrations of the trait under

discussion. During the Civil and Spanish wars the following words were fitted to them:[1]

14. REVEILLE.



I can't get 'em up,
I can't get 'em up,
I can't get 'em up in the morning.
I can't get 'em up,
I can't get 'em up,
I can't get 'em up at all.

The captain 's worse than the sergeant,
The sergeant 's worse than the corporal,
The corporal 's worse than the private,
But the major 's the worst of all.

[Then repeat first part.]

6. STABLE.

Come, come to the stable
All ye who are able,
Water your horses and get them some hay,

---

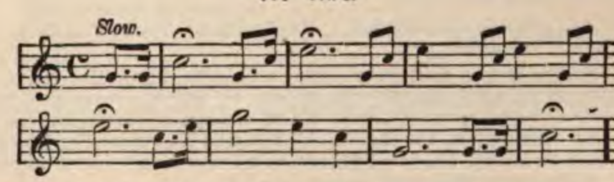
[1] For the electrotypes of the musical scores we are indebted to the courtesy of D. Appleton & Co., New York.

For if you don't do it
The colonel will know it,
And ho! for the guard house
The very next day.

18. MESS.

Soupy, soupy, soup, soup,
Without a single bean;
Porky, porky, pork, pork,
Without a streak of lean;
Coffee, coffee, coffee,
The vilest ever seen.

17. TAPS.



[The signal for lights out.]
Put it out, put it out, put it out, etc.

The words soldiers have put to this call when used in the burial services are:

"Love, good night, must thou go,
When the day and the night need thee so?
All is well.
Hasten all to their rest."

In the ordinary setting of words to music great liberty is taken with the quantity of the syllables used. In the present instances where words have been *fitted* to the music a more exact congruity may be expected, and the question may naturally be asked whether the notes represent with fair accuracy the true quantities of the syllables in question. This seems rather doubtful, especially in the case of the unstressed syllables. The cases are interesting, however, as showing the same rhythmic patterns fashioned from two sorts of rhythmic material.

LITERATURE.

La Folie: ses causes, sa thérapeutique, au point de vue psychique. Par TH. DAREL. Avec une préface du DR. E. GYEL. Geneva, M. Reymond; Paris, F. Alcan, 1901. pp. 196. Price, Fr. 3.50.

This essay, "un livre tout d'intuition," as the Editor terms it, is the outcome of a philosophy of 'psychism.' "The human individual is constituted by an extremely complex grouping of monads, themselves of very different stages of evolution. . . . . Such a group is naturally in a state of unstable equilibrium; and madness, that is to say the annihilation of the direction of the central monad, is the result of a rupture of equilibrium between the soul and the mental elements and between the mental elements and the 'astral' and material principle. The causes that predispose to insanity can all be traced to a lack of affinity between the soul and the secondary principles." We then have (1) hysteria, or insufficiency of central direction; (2) delirium of persecution, or rebellion of the mental elements from the ego, with subordination to the preponderant elements of the group; (3) mania and melancholia, or anarchy of the elements; and (4) dementia, or psychical disaggregation. The thesis is vigorously worked out; but most psychologists will prefer a less 'intuitive' account of the abnormal mind.

Socrate (Les grands philosophes). Par C. PIAT. Paris, F. Alcan, 1900. pp. 270. Price, Fr. 5.

This volume is the first of a series of works upon the leaders of philosophical thought, which will appear in quick succession under the general editorship of M. Piat. Kant, Avicenna, Malebranche, St. Anselm, St. Augustine, Descartes, St. Thomas Aquinas, St. Bonaventura, Maine de Biran, Pascal, Spinoza and Duns Scotus will form the subjects of the next following issues.

In the work before us, M. Piat treats of the life and teaching of Socrates in ten chapters, entitled respectively Social Surroundings, Youth, Vocation, Dominant Idea, Method, Ethics, Theology, Eschatology, Trial, and Influence. He writes pleasantly, and in popular vein; and, if he brings us nothing new, manages at least to cover his ground pretty thoroughly.

Experimental Psychology, by EDWARD BRADFORD TITCHENER. A manual of laboratory practice. Vol. I. Qualitative Experiments. Part I. Student's Manual. pp. 214. Price, $1.60. Part II. Instructor's Manual. pp. 456. Price, $2.50. The Macmillan Co., New York, 1901.

It is a pleasure to announce the appearance of this very important and long expected work, due notice of which will appear later. It was a misfortune, however, that the two parts did not appear together.

A Memorial of George Brown Goode. Annual Report of the Smithsonian Institution. U. S. National Museum, 1897, Vol. II. Washington, 1901, pp. 515.

The first thirty-eight pages of this interesting volume are devoted to abstracts of the remarks made by Gardiner Hubbard, Professors Langley, W. L. Wilson, H. F. Osborn, and W. H. Dall. Then follows

a twenty page memoir by Professor Langley, and the rest of the volume is devoted to papers on museums and the history of science in America, with a final bibliography of Goode's works. This book is made more interesting by full page plates of 109 of the most eminent men in the history of American science.

Götterglaube und Göttersagen der Germanen, von WOLFGANG GOLTHER. L. Ehlermann, Dresden, 1894. pp. 66.

This unique little book attempts a condensed statement of what the ancient Germans believed, and how they worshipped, and to present it all in historical perspective. The more important chapters are on belief in spirits, souls, elfs and giants, gods and the Supreme God of heaven, Wodan, Baldr, and other special deities, the creation and destruction of the world, divine service. The author evidently holds that this is not a bad faith to live and die by.

The Science of Life. An Outline of the History of Biology and Its Recent Advances, by J. ARTHUR THOMSON. Blackie and Son., Ltd., London, 1899. pp. 246.

This is an admirable compend of evolution in the field of biology, by a facile pen, with several dozen helpful titles in the way of bibliography.

Geschichte de Neugriechischen Volksschulwesens, von PAUL KIPPER. H. Starke, Grossenhaim und Leipzig, 1897. pp. 96.

This history of the Greek school system begins in 1827, when the present scheme was organized under French influence. It describes the gradual predominance of German influences and the development of the courses of lower and intermediate education, nearly up to its date, with copious references.

Erziehung und Erzieher, von RUDOLF LEHMANN. Weidmannsche, Berlin, 1901. pp. 344.

The chief topics discussed are the relations between education and heredity, habit, educational ideals, home, the departments, philosophy in the school. The latter chapter appears to the writer of this note the most important.

A Short Account of the Hebrew Tenses, by R. H. KENNETT. University Press, Cambridge. The Macmillan Co., New York, 1901. pp. 104. Price, $1.00.

The writer has found that students of Hebrew find special difficulty with tense, hence this primer designed to lead up to a fuller treatment of the subject in Driver's well known work.

The Books of the New Testament, by LEIGHTON PULLAN. Rivingtons, London, 1901. The Macmillan Co., New York, 1901. pp. 300. Price, $1.25.

This introduction is neither a mere handbook nor an elaborate treatise for specialists. It is conservative, yet has made ample use of recent critical investigation. It devotes a chapter to each of the main books with several interesting appendices.

A Text Book of Psychology for Secondary Schools, by DANIEL PUTNAM. American Book Co., New York, 1901. pp. 300.

This is an interesting book by a revered teacher of long experience. It is lucidity itself, as well befits the normal classes to whom the author ministered. His mind was conservative, and while most of his work is devoted to what some now call the old psychology, there are plenty of illustrations from the new, especially on some of the senses,

dreaming, hypnotism, and with suggestions for apparatus and experiment.

La Philosophie de la Nature chez les Anciens, par CH. HUIT. Thorin et Fils, Paris, 1901. pp. 583.

The author considers the relations of nature to religious thought among Hebrews, Persians, Egyptians, Chinese, and Hindus; the relations of nature to poetic sentiment in the literature of ancient Greece and Rome; and then treats of scientific and metaphysical nature study among ancient philosophers.

The Riddle of the Universe at the Close of the Nineteenth Century, by ERNST HAECKEL. Translated by Joseph McCabe. Harper and Brothers, New York, 1901, pp. 391.

There is a swan song which marks "the close of my studies on the monistic conception of the universe." The author renounces a system of monistic philosophy he had planned on account of growing age and weakening strength, and adds that "I am wholly a child of the nineteenth century and with its close I draw the line under my life's work." He here treats of life development, the soul, immortality, substance, nature, belief, monistic religion and ethics, in an easy and very interesting way interspersed by many fascinating reminiscences.

Problems of Evolution, by F. W. HEADLEY. Duckworth & Co., London, 1900. pp. 373.

First the writer tries to show that Lamarck is wrong as to the moulding influence of the environment, but he pleads for a world wide tendency to vary, and with natural selection as a regulating principle, so that all species, even the lowest, in a sense pilot themselves and heredity is progressively limiting the range of variation. With man the same principles as with the lower creatures are still operative, but others come in, so that civilization, though quite distinct from, is still guided by evolution. A discussion of the conditions that favor and oppose progress leads to a final chapter on China as unprogressive. The chapters on the interaction of species; the influence of the individual on the evolution of the race; on isolation; on moral, religious and intellectual evolution, are interesting and suggestive.

Evolution of To-day, by H. W. CONN. G. P. Putnam's Sons, New York, 1899. pp. 342. Price, $1.75.

These pages are intended for those who having an interest in the question have neither the time nor the requisite knowledge of biology to read the numerous special discussions on the various phases of the subject. Hence the chapters are—what is evolution; are species mutable; classification of the organic world; life during geological ages; embryology; geological distribution; Darwin's explanation of evolution; more recent attempts to explain it; the evolution of man.

Studies Scientific and Social, by ALFRED RUSSEL WALLACE. 2 vols., pp. 532, 535. Macmillan & Co., London, 1900.

These two volumes are mainly reprints of more important articles, which the author has contributed to reviews and other periodicals during the thirty-five years ending in 1899. He has, however, introduced many copious illustrations which modify and frequently enlarge the original articles. The range of the author's studies is perhaps better seen here than in any of his works. He has grouped the 42 essays under the larger headings of earth studies, descriptive zoölogy, plant and animal distribution, theory of evolution, anthropology, education, politics, the land problem, ethics and sociology.

Animal Behavior, by C. LLOYD MORGAN. Edward Arnold, London, 1900. pp. 344. Price, $3.00.

In attempting to revise the author's "Animal Life and Intelligence" for a new edition, it appeared "that the amended treatment would not fall conveniently under the previous scheme of arrangement," and he has, therefore, given us a new book. A few passages from the older work and some from his "Habit and Instinct" have been introduced or summarized. He treats organic behavior, consciousness, instinctive behavior, intelligent behavior, social behavior, feelings and emotions, and evolution of animal behavior. The work has a few illustrations.

The Laws of Orientation among Animals, by G. REYNAUD. Annual Report of the Smithsonian Institution, 1898. Washington, 1899. pp. 481–498.

In this discussion the author succeeds to his own satisfaction in eliminating all the theories that imply that homing birds or dogs are influenced by knowledge of the country, by geometrical triangulation, by the heavenly bodies, magnetic current, etc.; but thinks that in wintering creatures follow the lines of greatest attraction and least resistance, and the same principle brings them back.

Supériorité des Animaux sur l'Homme, par le DOCTEUR PH. MARÉCHAL. Fischbacher, Paris, 1900. pp. 228.

Animals are superior to us sometimes in senses, locomotion, metamorphosis and sex; in fighting the inconvenience of viviparousness; in having a more condensed mode of communication and often a more finished social organism. The author finds in animals the rudiments of medicine, religion, morals, science, and metaphysics. The writer's style is interesting and he marshals a large body of facts current in the literature of the subject in support of his hypothesis.

Dogs and Savages, by B. LANGKAVEL. Annual Report of the Smithsonian Institution, 1898. Washington, 1899. pp. 651–675.

This is a valuable digest of a very voluminous literature on the relations in many savage lands between dogs and human beings.

Gemüt and Gemütsbildung, von PAUL RÖNTGEN. Jos. Kösel'schen, Kempten, 1900. pp. 368.

These social and pedagogical studies are prefaced by an interesting statement of what the author conceives the *gemüt* is; its relation to knowledge, will, love, the heart, religion, character, while only the last 120 pages are pedagogical. It abounds in judicious quotations.

The Science of the Emotions, by BHAGAVÁN DÁS. Theosophical Publishing Society, London, 1900. pp. 183.

This work is inscribed to Annie Besant, by whose wish and under whose guidance it was written. It treats the factors of emotion; its essential nature; different kinds and subdivisions; relations of emotions; virtue and vice; complex emotions and their correspondents; emotions in art; in human life; and the high applications of the science of emotions. It is based largely upon Sanskrit sources, and comes into little contact at any point with occidental psychology.

La Foule Criminelle, par SCIPIO SIGHELE. F. Alcan, Paris, 1901. pp. 300.

This is a totally recast and enlarged second edition of the author's famous work, with new illustrative cases appended, and considerable reconstruction of the chapters.

An Essay on Personality as a Philosophical Principle, by WILFRID RICHMOND. Edward Arnold, London, 1900 pp. 219.

This essay is intended to illustrate a philosophical principle and not to establish a philosophical conclusion. Fellowship, the author thinks, would be quite as good a title. He first discusses experience and personality; their meaning and definition; then the faculties of personality, feeling, will and intellect. Perhaps the best chapter is the last on emotions, of which he makes love, and especially religious love, the highest type.

The Human Nature Club. An Introduction to the Study of Mental Life, by EDWARD THORNDIKE. Longmans, Green and Co., New York, 1901. pp. 235. Price, $1.25.

This somewhat enlarged edition rather needs the author's warning that too much must not be expected of a book which tries to handle psychological questions without technical words and without presupposing a knowledge of elementary science. It does indeed tell little truth, but it touches upon most of the large themes in current psychology, but so lightly and with such incessant paraphrase of James that we can but question the author's pedagogic success.

The Philosophy of Friedrich Nietzsche, by GRACE NEAL DOLSON. The Macmillan Co., New York, 1901. pp. 110.

This is a critical exposition of Nietzsche's writings so far as they are concerned with philosophy and an attempt to point out their historical position. Riehl thinks no serious German writer so widely read, and while Miss Dolson refuses to accede him the foremost place in the thinkers of all time, which his disciples claim, he is not a charlatan taking himself seriously, but a significant figure among the philosophers of his quarter century. The entire literary movement, known as young Germany, acknowledges his leadership. Indeed he is not an isolated phenomena, but a part of the general intellectual movement of the last decades, and thus expressing clearly what many have dimly thought, only perhaps more radically. After a brief biography and outline, this writer treats of his æsthetic, intellectual and ethical periods successively, and finally of his relations to Schopenhauer, Hegel, the materialists and Neo-Kantians, and also his literary affinities.

Sexual Debility in Man, by F. R. STURGIS. E. B. Treat and Co., New York, 1900. pp. 432.

The chief features of this book are the author's advocacy of castration of certain lunatics under special conditions, and his vigorous opposition to the old belief that masturbation is the prelude to both mental and physical degeneration. The first three chapters are devoted to the anatomy and physiology of his subject, while the rest treats of morbilities.

Uchronie (l'Utopie dans l'histoire), par CHARLES RENOUVIER. F. Alcan, Paris, 1901. pp. 412.

This is a very curious and interesting apocryphal historical sketch of the development of European civilization, not as it has taken place, but as it ought to have taken place. This is set forth in the story of a certain occidental Middle Age, which commenced in the first and ended in the fourth Christian century, and then in a modern occidental history ending in our own century. In the sequel he shows with great artistic talent what would have occurred if certain eminent historical percentages had formed other resolutions than they did, and what incalculable calamities would have followed if things had been

at their worst. Thus, while the optimist may rejoice that history has on the whole been as fortunate as it has been, the pessimist, if his ideals coincide with those of the author, will find justification because things might have been so much better.

Essai critique sur le droit d'affirmer, par ALBERT LECLÈRE. F. Alcan, Paris, 1901. pp. 263.

The author here treats of the principles and methods of a normal theory of being and of knowledge and more specifically of the Eliatic standpoint, unreality, the relations between conscience and reality, phenomena and reality. The second part is devoted entirely to the science of the non real, including phenomena in its relation to time, space and number; science and the activity of the soul; and the conditions under which a normal science of non-being is possible.

Un Siècle Mouvement du Monde de 1800 à 1900. Librairie H. Oudin, Paris. pp. 914.

This work is published by a committee centering in the Catholic University of Parigi and approved by Cardinal Rampolla. It consists of three parts, under each of which ten or twelve topics are treated, each by a different writer. The parts are political and economic, the intellectual and the religious movement of the closing century. Among the most interesting are those on education, philosophy, mathematics, biology, geology, archæology, history, literature, fine arts, music, physics and chemistry, and the press.

Audition colorée et Phénomènes connexes observés chez des écoliers, par AUG. LEMAITRE. F. Alcan, Paris, 1901. pp. 169.

After an interesting chapter on photisms and personifications of numbers, letters, etc., the author gives a number of diagrams of number forms, etc., from various sources, and then studies in detail the synopsia of three interesting subjects with copious illustrations. His interest centers in an attempt to explain genetically these curious phenomena.

On Artificial and Temporary Colour-Blindness, with an examination of the colour sensations of 109 persons, by GEORGE J. BURCH. Phil. Trans., London, 1899, Series B. Vol. 191. pp. 1–34.

The results of the author are unfavorable to the theory of Hering, and confirm that of Young and Helmholtz, but indicate the presence of a fourth color sensation, namely blue, which Young was prepared to admit if experimental evidence could be found.

Greek Thinkers. A History of Ancient Philosophy, by THEODOR GOMPERZ. Vol. I, translated by Laurie Magnus. Charles Scribner's Sons, New York, 1901. pp. 610.

This work summarizes the labor of a lifetime and will be complete in three volumes. It is not written from the standpoint of any exclusive school. It is here at last realized that historical relief is significant and that an outline of the story of religion, literature, and the special sciences is indispensable to an understanding of the speculative movement. The ideal is the universal history of the mind of antiquity. All critical discussion is wisely referred to notes, and the present volume prepares the way for the second which will begin with Socrates, while the third will end with mystics, sceptics, and syncretists.

Lehrbuch der Physiologie des Menschen, von G. von BUNGE. Erster Band. Sinne, Nerven, Muskeln, Fortpflanzung in achtundzwanzig Vorträgen. F. C. W. Vogel, Leipzig, 1901. pp. 381.

This first volume treats of the physiology of the senses, nerves,

muscles, and sex in the form of 28 lectures, with 67 cuts. The author's excuse in yielding to the demand of his students to publish is that now-a-days there are so few physiologists who teach over the entire field. The work certainly is not lacking in pedagogical lucidity, in condensation, or in apparent familiarity with first sources.

Trattato di Psichiatria del BIANCHI LEONARDO. Napoli. Puntata I. L. 4. pp. 170.

This treatise, designed for the use of medical students, the first part of which is here published, promises to be one of the best compends in any language. We can but wish that the author had given more attention to his literary references in many cases, as he cites many names to some of which the reader would naturally be prompted to turn.

The Christian Doctrine of Justification and Reconciliation, by ALBRECHT RITSCHL. English Translation, edited by H. R. Mackintosh and A. B. Macaulay. Imported by Charles Scribner's Sons, New York, 1900. pp. 673. Price, $4.00.

No work since Schleiermacher's *Christliche Glaube*, in 1821, has caused so deep a movement in the field of theology as this monumental treatise, the first edition of which appeared in Germany in 1870–74. This is the English translation of the third volume of the third edition of the original, which presents on the whole the main features of the author's view. The first shows that Ritschl's theology had no place in the ordinary classifications of theological parties, and the second exhibits the biblical material of his doctrine here summed up under the leading captions of the conceptions of justification, its presuppositions, proof and consequences.

Clue. A Guide through Greek to Hebrew Scripture, by EDWIN A. ABBOTT. A. and C. Black, London, 1900. pp. 158.

This work attempts to indicate means for constructing a clue by which scholars may systematically find their way through any Greek translation from Hebrew back to the Hebrew original; secondly, to demonstrate that parts of the synoptic gospels are based upon a common Hebrew document; and thirdly, to give specimens of the manner in which the clue may be used so as to return from the gospels to the original Hebrew. The chapters of the first part treat the errors of conflation in the pentitude, and of the second those in the synoptic gospels.

The Christology of Jesus, by JAMES STALKER. A. C. Armstrong & Son, New York, 1899. pp. 298. Price, $1.50.

The writer treats his matter in six chapters—the importance of the teaching of Jesus, the Son of man, the Son of God, the Messiah, the Redeemer, the Judge; with two appendices, one on Wendt's untranslated volume on the teaching of Jesus and the other on the book of Enoch.

God's Education of Man, by WILLIAM DEWITT HYDE. Houghton, Mifflin & Co., Boston, 1900. pp. 252. Price, $1.00.

The author here attempts to indicate in a general way and also uses a single small section to point out in considerable detail the radical and far reaching change which is taking place in theological conceptions. The more theological introduction treats of the reorganization of the faith; chapter 1 of control by law; chapter 2 conversion by grace; chapter 3 character through service, while in the conclusion a somewhat alien matter on two types of ideals is added. These are Plato and Aristotle; Kant and Hegel; Arnold and Browning; Garrison

and Lincoln; Burne-Jones and Watts; and of missionaries Nott and Anderson, Hamlin and Livingstone.

Goethe's Selbstzeugnisse über seine Stellung zur Religion und zu religiös-kirchlichen Fragen, von TH. VOGEL. B. G. Teubner, Leipzig, 1900. pp. 242.

The self evidences of religion, Goethe finds, as interpreted by this book, in the impulsion toward the sublime found in reverence and worship; in the idea of God and nature; the worth of humanity; body and mind; working and warring; patience, renunciation, unrest, penance, immortality. His expressions also are summarized upon the following topics:—revelation and scripture, miracle, Christ, primitive Christianity, the visible and invisible, church, and church history.

Ethics: Descriptive and Explanatory, by S. E. MEZES. The Macmillan Co., New York, 1901. pp. 435. Price, $2.60.

This work is dedicated to the author's first teacher in philosophy, Professor G. H. Howison, and attempts to give a critical and methodical account of what morality and immorality really are. The chapter heads best indicate its scope. They are definition and methods; moral and non moral phenomena; subjective morality; voluntary action; the adult conscience; its psychic law; birth and growth of conscience in the child; in the race. The second part treats of objective morality, and more specifically the constituents and criteria of objective morality, courage, temperance, benevolence, justice, wisdom, welfare, the nature and value of morality. We have glanced critically at only the chapters on the growth of consciousness in the individual and in the race, because these are the newer topics and best calculated to reveal the author's method and his thoroughness, but both sections are aridly speculative and show almost no acquaintance with the interesting new literature in this field. In general the work moves in the sphere of the common speculative ethics of the schools.

The Evolution of Immortality, by S. D. MCCONNELL. The Macmillan Co., New York, 1901. pp. 204. Price, $1.25.

This is one of those exasperating books without an index or even a heading to its chapters, so that there is absolutely no point of approach. One must either read it through, or sample it, or give it up. We have done the two latter. There are to-day restless minds with an intellectual psychosis akin to that of tramps, who rove over the whole world of knowledge in a light easy going way; know a little of Darwin and have heard of Wundt and Haeckel; have dabbled in patrology; spice their pages well with poetic extracts, stray sentences from travellers, theologians, physicists, Bible critics, and historians; give long lists of great names, who think thus and so, but intersperse them in an uncritical way with popular modern writers utterly without authority; whose chapters might be placed in any other order, because there is no real continuity or progress. We by no means state that this author is thus described, but we do assert emphatically that from our standpoint his contribution to this most important subject is disappointing in the extreme, and that he shows throughout little or no knowledge of what seems to us an important contingent, viz., the anthropological and psychological treatment of his theme.

History, Prophecy and the Monuments, by JAMES FREDERICK MCCURDY. Vol. I, pp. 425; Vol II, pp. 433; Vol. III, pp. 470. The Macmillan Co., New York, 1896, 1897, and 1901. Price, $3 per volume.

The writer here attempts to cover all the period in Jewish history, which are illustrated by contemporary monuments, and seeks to get

these, with the author's introductory chapter explaining why he is not a positivist, constitute the book.

The Bee People, by MARGARET W. MORLEY. A. C. McClurg and Co., Chicago, 1900. pp. 177.

Miss Morley here writes with a little of the old charm that made The Songs of Life so justly popular, but which seemed to have faded from her Life and Love. She illustrates as well as writes, and this adds greatly to the effectiveness of her work.

The Ethics of Judaism, by M. LAZARUS. Translated from the German by Henrietta Szold. In four parts. The Jewish Publication Society of America, Philadelphia, 1900. Part I, pp. 309.

This is a scholarly history, which carefully refrains from comparisons with other modes of thought save only in the case of von Hartmann, whose charge against every system of ethics based on theism is refuted. The three chapters of this volume are—the sources, principle, and character of Jewish ethics. The other three volumes will be awaited with interest.

Psychologie und Pädagogik des Kinderspiels, von G. A. COLOZZA. Oscar Bond, Altenburg, 1900. pp. 272.

The first chapter discusses play from the standpoint of psychology; the second gives its history in pedagogy; and the third details its pedagogic significance for suggestion, invention, physical training, development of eye, ear, touch, muscle, sense, memory, attention, feeling, etc. Fighting is commended in its season and with moderation. Solitude vs. sociability for children is discussed; toys, especially the doll, and their relation to the æsthetic feeling and imagination; the advantages and disadvantages of illusion and its relations to work are taken up.

The Philosophy of History, by A. SCHADE. A. Schade, Cleveland, O., 1899. pp. 437.

This is a most scholarly work, covering with its comprehensive formula the entire course of history, and thoroughly inductive in method. Progress in history is measured by the degree in which feeling, reason, and will are brought under the control of a free agent into equilibrium and proper mutual co-ordination. In this encyclopædia of all knowledge, Christianity and its ethics and church are made the center. The convenient marginal notes are a great aid to the reader.

Diseases of the Heart, Blood Vessels, Lymphatics, Blood and Ductless Glands. M. J. Breitenbach Co., New York.

This is an interesting and very condensed chart in the following columns:—name of disease, cause, symptoms, inspection, palpation, percussion, osculation, pulse, complication.

La Suggestibilité, par ALFRED BINET. Schleicher Frères, Paris, 1900. pp. 391.

The chapters are history, directive ideas, moral action, interrogation, imitation, conclusion. The work is a part of the author's larger plan of amassing material to shape an experimental psychology of the higher functions of the mind with a view to the differentiation of individualities. The two questions here treated are, whether effective suggestibility can be secured without hypnotism or to determine the degree of suggestibility, and the second to decide whether these or other tests of suggestibility are significant. Both these questions the author answers in the affirmative.

Die Mimik des Menschen auf Grund voluntarischer Psychologie, von HENRY HUGHES. J. Alt, Frankfurt, A. M., 1900. pp. 423.

In his introduction the author discusses the history and literature of mimic and gesture, and then takes up its psychological basis, under which he discusses his methods, its individual origin and differences, historical development from the animals up, and relation to art. The third chapter treats of movement of the face,—the forehead, eyes, nose, mouth, and ears; the fourth, movements of the body,—the head, arms, and legs; and the fifth treats the mode of expressing emotion under the rubrics,—the voluntary principle, composition of impulses, feelings, excitation of gemuth and will, mood, attention, inclination, and *achtung*.

The Mystic Self. Uncommon Sense vs. Common Sense, by RAYON. Chicago, 1900. pp. 70.

Mystic signs; a serpent; a radiant hand; three full-page photographs of Elfa among the people; in a magnetic sleep separating the two selves; and the physical self-dormant, the higher self away at work; a maze of quotations.

Dix Années de Philosophie. Études Critiques sur les Principaux Travaux Publiés de 1891 a 1900, par LUCIEN ARRÉAT. F. Alcan, Paris, 1901. pp. 179.

This is an attempt to outline the history of philosophy of the last decade under the rubrics—sociology, psychology, æsthetics, manners, religion, and doctrine. The writer names and briefly characterizes the leading works in this field, and has given us an interesting book.

Freedom and 'Free-Will,' GEORGE STUART FULLERTON. Popular Science Monthly, LVIII, 1900. 183-192.

"Freedom" implies absence of external compulsion; "Free-Will," absolute independence of objective and subjective influences. The former, all covet; the latter Mr. Fullerton denies. He, therefore, favors the view of determination, not fatalism, that we can do as we please, but that there is always a sufficient reason for the "as we please." The paper is a clear and popular restatement of Jonathan Edwards's view.

A. J. KINNAMAN.

Rhythm as an Aid to Voice-Training, by SARAH ALLAN JORDAN. Association Review, II, 16-19, Feb., 1900.

The author holds that man is born with the possibilities of a sense of rhythm, and that this can be made an educational factor in training the deaf mute to speak as the hearing child speaks, and in removing the defects of tone, modulations, and manner of speaking of the deaf child. The sense of rhythm is to be developed through bodily movements, and then applied in the speaking movements. The material for the training in speaking are, jingling rhymes, poetry, etc. As means for securing an understanding of differences in pitch, the author mentions the pipe organ and piano.

M. K. SMITH.

Essai sur l'esthétique de Lotze. Par A. MATAGRIN. Paris, F. Alcan, 1901. pp. 166. Price, Fr. 2.00.

Based upon Rehnisch's *Grundzüge*, 1884. Pt. i, discusses beauty,—its objective and subjective bases, its definition and modes. Pt. ii, discusses art in general and the arts in particular, giving Lotze's classification. A brief critical and historical study ends the volume.

Psychologie de l'invention. Par F. PAULHAN. Paris, F. Alcan, 1901. pp. 185. Price, Fr. 2.50.

An interesting and suggestive discussion (1) of invention, 'intel-

lectual creation,' in general, and its relation to affective and volitional processes, to imitation and routines; and (2) of the development of invention by evolution, transformation, and deviation, and of the corresponding developments of imitation and routine. General considerations of the place of invention in society: its relations to life, instinct, and chance, its range and philosophical significance.

Crime and Criminals. By J. S. CHRISTISON. Second ed., 1899. Chicago, J. S. Christison. pp. 177. Price, $1.25.

Expanded reprint of papers on 'Jail Types' published in the Chicago *Tribune*. Distinction between the insane (defective in reason); the moral paretic (defective in self-control); and the criminal (defective in conscience). Sketches of cases (including Windrath and Luetgert). Cause and cure of crime; prison treatment.

The Political Economy of Natural Law. By H. WOOD. Boston, Mass., Lee & Shepard, 1899. pp. 305. Price, 50 cents.

Conventional political economy is unpractical, and therefore of little service in actual experience. We must attack the labor problem in the light of natural law, and improvement must come through a better interpretation of (and conformity to) its immutable lines.

History of Ancient Philosophy. By W. WINDELBAND. Translated by H. E. Cushman New York, Chas. Scribner's Sons, 1899. pp. xv, 393. Price, $2.00.

We are glad to give a word of commendation, though tardily, to this excellent class-book of Greek and Hellenic-Roman philosophy. It is a valuable addition to the apparatus of philosophical teaching.

Sanity of Mind: A Study of its Conditions and of the Means to its Development and Preservation. By D. F. LINCOLN. New York, G. P. Putnam's Sons, 1900. pp. vi, 177.

Chapters on mental derangement, degeneracy, education, and self-education. Recommendation of "custodial care of the classes known as the insane, the feeble-minded or idiotic, the epileptic, inebriates, criminals, tramps, and paupers," with a view to restrict or wholly prevent the propagation of a new generation.

Hypnotism a Complete System of Method, Application and Use, Prepared by the Self-Instruction of the Medical Profession. By L. W. DE LAURENCE. Second ed., illustrated. Chicago, The Henneberry Co., 1901. pp. 256. Price, $1.50.

Magic, White and Black: the Science of the Finite and Infinite Life, Containing Practical Hints for Students of Occultism. By FRANZ HARTMANN. Sixth ed., revised. New York, The Metaphysical Publ. Co., 1901. pp. 292. Price, $2.50.

Neither of these books has any scientific value. The former lays down practical rules, from the platform standpoint, for the induction of the hypnotic state: the chapter on the psychology of hypnosis gives no hint that the author knows anything of the physiology or psychology of his subject. The latter invites its readers to "rise mentally into the highest regions of thought and remain there as its permanent residents," or, more concretely, to raise the magic wand of their wills and still the tempests raging in the astral plane. It is significant that both books are, apparently, finding an extended sale.

Fact and Fable in Psychology, by JOSEPH JASTROW. Houghton, Mifflin & Co., Boston and New York, 1900. pp. xvii+375. Price, $2.00.

To speak of a scientific work in certain circles as "popular" is to

damn it and that without even faint praise. At the same time if science is to do its work for mankind, its standpoints and general results must somehow be made accessible to all intelligent men. There is need and opportunity for the genuine interpreter of science as well as for the specialized producers of new facts. It would therefore be in hearty commendation if the reviewer should describe this collection of Prof. Jastrow's previously published essays as a popular work in the best sense. The matter and method are interesting, and both the scientific attitude and dignity of presentation are preserved throughout. But the book is considerably more than that. All of the essays represent a fresh and first-hand treatment to the questions considered, and several embody the substance of valuable original contributions. The titles of the main group show sufficiently both the topics and the range of the treatment: The Modern Occult. The Problem of Psychical Research. The Logic of Mental Telegraphy. The Psychology of Deception. The Psychology of Spiritualism. Hypnotism and its Antecedents. The Natural History of Analogy. The Mind's Eye. Mental Prepossessions and Inertia, and A Study of Involuntary Movements. To have brought together in one readily accessible place so much that bears upon such an important chapter of anthropological psychology is itself a contribution. Prof. Jastrow's attitude toward "Psychic Research" (to use one term for the whole group) is that of the majority of competent authorities, namely, that the phenomena are worthy of study; that they can often be brought into line with known principles of physics, physiology and psychology; and that the presumption is overwhelmiug, even in the most remarkable and apparently inexplicable cases, that these also would fall into line, could absolutely full and reliable data be obtained. The last essay in the book is on the Dreams of the Blind, and furnishes an excellent indication of what might be expected from a thorough study of the psychology of defectives by a competent hand. This and the essay on Mental Prepossessions and Inertia are full of pedagogical suggestions.

E. C. S.

Recent Advances in Psychology. By E. B. TITCHENER. International Monthly, August, 1900.

In fourteen pages the writer presents a few points in vindication of the "new psychology," reviews and comments upon some of the results achieved in the fields of sensation and perception, attention and feeling, notes some features of the progress in genetic, animal and social psychology, and makes critical reference to some of the recent literature.

F. H. SAUNDERS.

The Psychology of Crazes. By G. T. W. PATRICK. Pop. Sci. Mo., LVII, No. 3, 1900. pp. 285-294.

The hypnotic phenomena and the reversionary mentality and morality exhibited by individuals in mental epidemics and crazes are due to the fact that the unusual excitement accompanying excessive emotion exercises an inhibitory effect upon the higher brain centers. The physical phenomena so common in mental epidemics tend to confirm this theory, for in excessive emotion the unusual excitement in the lower brain centers finds its expression through the motor channels. The last part of the article is devoted to the application of the theory to special cases taken from history.

The Angle Velocity of Eye Movements, by DODGE AND CLINE. Psychological Review, March, 1901. pp. 145-157.

After brief critical illusion to the methods of Volkmann, Lamansky and Huey in this field the authors state in five points the ideal ex-

perimental requirements for apparatus to record eye movements. Their own apparatus consisted of a sensitive film which could move easily in the vertical plane behind a narrow slit in the plate-holder of a camera. In the experiments the movement of a bright vertical line reflected from the cornea was photographed on the moving film. The averages of the measurements are compared with those obtained by Huey, and the peculiarities of the times found by the latter are accounted for as due to the necessary inertia of his apparatus.

F. H. SAUNDERS.

Psychological Observations of Spiritism. By TH. FLOURNOY. Reprint from the Proceedings of the International Congress of Psychology, Paris, 1900.

The author deprecates the attitude of regular science towards the phenomena loosely grouped under the term "Psychical Research," and holds that psychology would do well to investigate this subject concerning the nature of which the number of earnest inquiries is constantly increasing.

Prof. Flournoy has himself made a series of investigations, insufficient as a basis for generalizations, but sufficient to justify a distrust in the doctrines of Spiritism and Occultism. In no case has he found a single instance in their favor. A vast majority of cases may be referred to *unconscious perception and latent memory* by means of which material is preserved which may be used later by the "Subliminal Imagination" in constructing fictions singularly independent of the minds in which they originate. The facts given refer to his already previous use of Helene Smith described in his work "From India to the Planet Mars." (See this *Journal*, XI, 428, and XII, 265.)

The author recommends a careful psychological and logical study of the fallacies by which mediums and adepts deceive themselves.

MARGARET K. SMITH.

THE 'MIND' ASSOCIATION.

Owing to the death of Professor Henry Sidgwick, who had borne the financial responsibility for the conduct of *Mind* since 1892, as Professor Alexander Bain had borne it from 1876-1891, there has been formed in England a 'Mind' Association, the object of which is to make the journal independent of private liberality, and to put it upon a sound financial basis. The membership fee is one guinea, in return for which each member of the Association receives a copy of *Mind*. Though the Association is primarily a body of subscribers, it has the secondary function of organizing and stimulating philosophical interest. The leading British philosophers of the day are now members of the Association, and it may be confidently anticipated that they will co-operate in making *Mind* thoroughly representative of every side of philosophical thought.

Subscriptions from America may be sent to Professor E. B. Titchener, Cornell University, Ithaca, N. Y.

CORRESPONDENCE.

MY DEAR DR. TRIPLETT:

In a letter recently received, Prof. Dessoir takes exception to the statement in your letter to the Editors in the October number of the *Journal* "that several citations have been credited to Dessoir that are to be found in Jastrow's original paper," and points out that he gives Prof. Jastrow credit by referring in foot notes to two of his papers, and further that, in two out of the three instances in which you refer to his own work, you cite passages to the formulation of which he was certainly led by his own personal observations. In the third instance you have apparently been misled by a translation which is defective at this point, or possibly by a misplaced reference sign which occurs at the same place in the original, if you consulted that. The matter is perhaps a small one, but in view of your statement above quoted, some further explanation would seem desirable.

Yours very truly,
E. B. TITCHENER.

MY DEAR PROF. TITCHENER:

I gladly avail myself of the opportunity of your letter to correct the careless statement in my letter to the *Journal*. It is true that for "several" I should have written "one;" I regret to have been thus inaccurate. In this one instance, however, the wording of Prof. Dessoir's and Prof. Jastrow's articles is practically identical, and the inference was natural that the earlier writer should have the credit. Reference to Prof. Dessoir's original paper shows the translation to be defective, as you say—though at the time of writing I was not aware of it—and also the misplacement of the reference, for which of course I am hardly responsible.

Yours very truly,
NORMAN TRIPLETT.

BOOKS RECEIVED.

CLAPARÈDE, ED. Les animaux sont—ils conscients? Eggimann & Cie, Genève, 1901. pp. 24.

DAREL, TH. La folie, ses causes, sa thérapeutique au point de vue psychique. Avec une préface du Dr. E. Gyel. F. Alcan, Paris, 1901. pp. 196. Price, Fcs. 4.

DE LAURENCE, L. W. Hypnotism. The Henneberry Co., Chicago, 1901. pp. 256. Price, $1.50.

DOLSON, GRACE NEAL. The philosophy of Friedrich Nietzsche (Cornell Studies in Philos., No. 3). The Macmillan Co., New York, 1901.

FLOURNOY, TH. Observations psychologiques sur le spiritisme. Extrait des Comptes-Rendus du IV e Congrès Int. de Psy. F. Alcan, Paris, 1900. pp. 11.

HARTMAN, FRANZ. Magic, white and black. The science of finite and infinite life containing practical hints for students of occultism. The Metaphysical Pub. Co., New York, 1890. 6th ed. pp. 292. Price, $2.50.

JOLY, HENRI. Malebranche (Les grands philosophes). F. Alcan, Paris, 1901. pp. 296. Price, 5 fcs.

MASON, R. OSGOOD. Hypnotism and suggestion in therapeutics, education, and reform. H. Holt & Co., New York, 1901. pp. 344. Price, $1.50.

Saunders's Medical Hand-Atlases. The Nervous System, by Dr. C. Jakob. Edited by Dr. E. D. Fisher. From the 2nd revised German edition. W. B. Saunders & Co., Philadelphia, 1901. pp. 218, with 83 plates. Price, $3.50.

THORNDIKE, EDWARD. The human nature club. An introduction to the study of mental life. Longmans, Green & Co., New York, 1901. pp. 235. Price, $1.25.

TITCHENER, EDWARD B. Experimental psychology. A manual of laboratory practice, Vol. I. Qualitative experiments, Part I, Student's Manual. pp. 214. Price, $1.60. Part II, Instructor's Manual. pp. 456. Price, $2.50. The Macmillan Co., New York, 1901.

WOOD, HENRY. The political economy of humanism. Lee & Shepard, Boston, 1901. pp. 319. Price (cloth), $1.25.

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Courses of Instruction offered by the Department of Psychology for the academic year 1901-2.

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JULY—OCTOBER, 1901.

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AN ANALYTIC STUDY OF THE MEMORY IMAGE AND THE PROCESS OF JUDGMENT IN THE DISCRIMINATION OF CLANGS AND TONES.

By GUY MONTROSE WHIPPLE, A. B., Ph. D., Assistant in Psychology at Cornell University.

INTRODUCTORY.

During the winter of 1897-98, the writer, then a student at Clark University, was attracted to the problem with which the present investigation deals by the observation of several rather unusual instances of 'pitch memory.' These observations led to an experimental investigation which was instituted with a view of analyzing qualitatively the structure of such processes of discrimination. The tests were, however, of an unsystematic nature, and were mainly restricted to personal observations conducted with the aid of a piano.

The more detailed and systematic study of the problem, the results of which are embodied in the present paper, was undertaken in the Psychological Laboratory at Cornell University during the academic years 1898-99 and 1899-1900. An added interest was given to the problem, and a favorable setting secured for the necessary experimentation, by the fact that there had just been completed in the same laboratory an essentially similar study in the domain of vision.[1]

Since this article fully discusses the general bearing of the problem in hand, the present paper needs but little introduction. It may be well, however, to recount briefly the features of the preceding work which bear especially upon the prob-

[1] I. M. Bentley: The Memory Image and its Qualitative Fidelity, this *Journal*, XI, 1899, 1-48.

lem, and also to make preliminary mention in this place of certain previous publications upon pitch memory which must necessarily be handled in some detail in the discussion of our results.

Setting out from Kuelpe's contention that much of the work on memory has assumed without sufficient cause the presence of a memory image, and that the term has been too loosely applied, Bentley has given a review of the literature bearing upon the memory image and the methods of its investigation, has discussed its genesis and function, and conducted an experimental study of the qualitative fidelity of memory images of color and brightness. He points out that the modern laboratory researches in this field have been chiefly pedagogic and popular rather than analytic in nature.[1]

The chief methods for the study of the image are those of reproduction, recognition, comparison, and description. In view of the schematic nature of the reproduced elements, an important analytic problem is afforded if we seek to determine not how much of a given impression can be reproduced, but what is the nature of the centrally excited processes which form the basis of the act of reproduction or of recognition.

Both Wolfe[2] and Lehmann[3] assumed the presence of a memory image in the recognitory consciousness; Hoeffding[4] posited an unanalyzable 'quality of knownness' which had its physical substrate in a certain ease of molecular movement in the cortex; Washburn[5] has advanced the hypothesis that recognition is a peculiar property of centrally excited sensations, possibly mediated by the excitation of connective brain tracts; Kuelpe[6] has mentioned effectiveness for the arousal of centrally excited sensations *plus* a mood of familiarity; Baldwin[7] the ease of motor adjustments of attention; and Wundt[8] a feeling of recognition supported by a background of ideas.

Perception, like recognition, does not necessarily include reproduction, although it involves the past experience of the individual. We may arrange a schema of types of meaning-consciousnesses which shall show at a glance the part played by the image. Such a schema is given herewith:

1. Cognition (perception): no image introspectively discoverable.

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[1] The articles of Philippe, *Rev. phil.*, Vol. XLIII, 1897, 481-493, *ibid.*, Vol. XLIV, 1897, 508-524, by their emphasis of the analytic study of the image for its own sake, form a pleasing exception to this tendency.
[2] *Phil. Stud.*, III, 1886, 556-558.
[3] *Phil. Stud.*, V, 1889, 118-119.
[4] *Vierteljahrsschrift*, 1899-90.
[5] *Phil. Rev.*, VI, 1897, 267.
[6] Outlines of Psychology, 1895, p. 172.
[7] Mental Development, 1895, 313 ff.
[8] *Phil. Stud.*, VII, 1892, 344 ff.

2. Recognition.

A. Direct recognition : no image is necessary (whether the process be conducted with active or passive attention) save in the form of direct recall (memory in the narrow sense).

B. Mediate recognition : when it involves conscious comparison an image is implied, but otherwise auxiliary ideas or other motives may be sufficient.

Bentley's experimental tests were conducted mainly by the method of recognition, with special precaution to secure knowledge of the presence or absence of the image just at the end of the time-interval. In the first series, conducted with open eyes, the observers did not try to hold the brightness image. Images were present in five-sixths of the tests. They could be recalled better at the end of five minutes than at the end of one minute. On the other hand, there were frequent instances of flash-like, absolutely certain judgments, where there is no trace of comparison and no vestige of an image,—judgments in which "the work seems to have all been done for consciousness."[1] There was a constant tendency toward lightening of the imaged brightness. The second series proceeded by a continuous change method. The results showed that the method hindered the employment of the image in processes of comparison, and that the individual variations were large. Although the standard was approached from two directions, yet a large amount of expectation might obscure any constant memory error. The quantitative results exhibited large mean variations.[2]

The third series reported by Bentley was made by the method of right and wrong cases, with special regard to the stimulation of the retina during the interval (2–60 secs.). In these tests the observer was asked to hold the image actively. The result of non-stimulation of the retina during the interval was to darken the brightness image. The amount of darkening and consequent loss of accuracy increased slowly from 2 to 60 seconds, but without the peculiar periodicity asserted by Wolfe and others.

In conclusion Dr. Bentley adds: "Simple recognition stands much nearer positive or negative identification (expressed by affirmative or negative judgments) than it does to pure memory, and the alleged act of comparison with a memory image is rather a logical formulation, suggested by the judgments 'like' and 'different,' than a psychological statement of fact. Where the image is available memory is slightly more accurate," but recognition may be sure and precise when the image plays no part.

The experiments of Wolfe[3] by the method of right and wrong cases

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[1] Chronoscopic measurements of such immediate judgments, in the case of recognition of tones, will be given later.

[2] A detailed discussion of the application of this method to the problem in audition will be given later.

[3] *Phil. Stud.*, III, 1886, 534-571.

are, as regards the materials (clangs of the Appunn tonometer) and the intervals employed (mainly 2 to 60 seconds), more in accord with those of the present investigation than the experiments upon the fidelity of the visual memory image just reviewed, although in their essential purpose, since they were concerned with a functional investigation (the capacity for tonal recognition as conditioned by time interval), they are not at all closely allied to our experiments. More especially, Wolfe, as has already been mentioned, assumed that the quotient r/n (method of right and wrong cases) measured the fidelity of the memory image. This assumption depends in turn upon the hypothesis that the image is always actively present in the judgment. Thus he says (p. 556): "Gehen wir naeher auf das Verfahren beim Vergleichen zweier durch einen Zeitraum getrennten Toene ein, so ist klar, dass ohne ein Erinnerungsbild des ersten Tons eine Vergleichung ueberhaupt unmoeglich ist. Dieses Erinnerungsbild ist gewissermassen der Massstab, an welchem der zweite oder Vergleichston gemessen wird." This quotation should be qualified by the following (p. 558): "Es ist aber bekanntlich nicht noetig ein bleibendes Bild im Bewusstsein zu behalten, um eine Vergleichung zu vollziehen. Selbst wenn keine bewusste Spur des ersten Tones zurueckbleibt, ist ein Urtheil oft moeglich, *indem der zweite Ton sofort ein Bild des ersten hervorruft.*"

The tone differences employed by Wolfe were 4, 8, and 12 vibrations;[1] the categories of judgment were 'same,' 'different' (higher or lower) and 'doubtful.' The results of the series with 4 vibs. D showed that there were more right cases with D=0 than with D=$\pm$4 vibs. The series with D=8 vibs. showed that the comparison of different tones (D=$\pm$8) was less influenced by time-interval than was the recognition of the same tone as 'same' (D=0). In the series with D=12 vibs. there were still instances, even at four seconds interval, in which difference was recognized, but not the direction of the difference.

The discussion of the dependence of the results upon time-interval brings out the following statements. Despite many disturbing individual factors, more especially that of practice, it may be said that, in general, fidelity of the memory image for pitch decreases in such a manner that the time-interval must increase approximately in geometrical progression in order to effect equal amounts of decrease of retentiveness.[2] The optimal time for judgment is at 2 secs. At between 10 and 20 seconds (depending upon the observer) there is a rise in the number of right cases which may indicate, according to Wolfe, not only a cessation of the disintegration, but a positive renewal of the image. Whether the explanation be in terms of large periodic variations of apperception (attention to the image) or of the influence of

[1] In every case D=0 was included.
[2] This law is based upon the results for D=0.

tonal after-images,[1] the periodicity, as evinced by the curve of right cases, remains an assured fact. The phases of clearness in the image may be assumed to be approximately constant for the same individual and the same degree of effort. The periodicity, therefore, points to a like periodicity in the attention, since clearness of memory is assumed to be dependent upon the attention.

Other general results are that D=o is oftener judged higher than lower; higher is oftener judged correctly than is lower, and lower is oftener judged higher than higher is judged lower. These results are due to the fact that there is a tendency to estimate the memory image owing to its lessened intensity, as lower than an actually heard tone of the same pitch. Practice effects are prominent in the early stages especially in the case of unmusical subjects. Such practice effects seem to be rather restricted in their application; thus Wolfe, who was unmusical, became able to discriminate higher from lower with considerable exactness with a D=4 or 8 vibs., but curiously enough was then far less certain with a D of 30 or 40 vibs.

Our general criticism of the work of Wolfe can be well emphasized at this point by a quotation from the recent monograph by Martin and Mueller.[2] It is a source of satisfaction to find that these authors, whose general purpose, as indicated by the title of their work, is identical with our own, have made express mention of the desirability of investigations along lines which our experiments have attempted in part to cover. After referring to the experimental setting of Wolfe's work they say (pp. 230-1): "Man hat nun die Ansicht ausgesprochen, dass die Resultate derartiger Versuche ohne Weiteres geeignet seien, uns Auskunft darueber zu geben, wie die Treue der Erinnerung an den Normalton (oder sonstigen Normalreiz) im Verlaufe der Zeit abnimmt. Diese Behauptung laesst die erforderliche Vorsicht des Denkens vermissen. Aus Resultaten von Versuchen der soeben erwaehnten Art kann man betreffs des Ganges, den die Treue der Erinnerung im Verlaufe der Zeit nimmt, offenbar nur dann etwas erschliessen, wenn man zuvor in wissenschaftlicher Weise etwas Sicheres ueber die Beziehung ausgemacht hat, in welcher die Resultate derartiger Versuche zu der Treue der Erinnerung stehen, also zuvor den Vorgang, welcher bei Vergleichung eines Sinneseindruckes mit einem vorausgegangenen Sinneseindrucke stattfindet, nach allen wesentlichen Seiten hin sicher aufgeklaert hat. Zur Zeit liegt aber ein ernstlicher Versuch, eine Aufklaerung ueber das Wesen dieses Vorganges zu erlangen, . . . ueberhaupt nicht vor."

While it is scarcely desirable to recount the experiments of Martin and Mueller, because of the disparity between their materials (lifted weights) and tones,—a disparity which is accentuated by the introduc-

[1] "Eine periodische Tendenz zur Erneuerung einer Tonempfindung eine Zeit lang nach dem Aufhoeren des Reizes fortexistiert" (p. 557).
[2] Zur Analyse der Unterschiedsempfindlichkeit, Leipzig, 1899.

tion of an important and complicated factor, that of active movement upon the part of the observer,[1]—yet it seems fitting to make specific reference here to this monograph as a noteworthy contribution to the analytic study of the judgment process. This emphasis of analysis as the ultimate problem of the psychologist is well expressed upon page 225: "Man wird mit uns darueber uebereinstimmen, dass fuer die Psychologie nicht die Untersuchung jener irgendwie definirten Unterschiedsempfindlichkeit die letze Aufgabe ist, sondern die Untersuchung der Factoren, auf deren Wirksamkeit die Urtheile ueber die zu vergleichenden Sinneseindruecke und die Besonderheiten dieser Urtheile beruhen. Jeder jener Factoren ist, so weit es eben geht, hinsichtlich seiner Natur und Wirkungsweise und hinsichtlich seiner Abhaengigkeit von den Versuchsumstaenden zu untersuchen." Such of the detailed results of this monograph as are applicable to the sphere of audition will be discussed later.

In an article upon the "Experimental Investigation of Memory,"[2] Kennedy has entered a plea for the analytic study of the memory image. Thus he says (p. 484): "The general problem of memory, as it is now conceived, is that of tracing the transformations which take place in each content as it passes through time." But it is evident that Kennedy still holds to the necessity of an image in the judgment process. We quote from page 485. "In order that a certain object be remembered it is necessary . . . that some image of it be retained after it has gone." The words "some image of it" leave, perhaps, room for misinterpretation: still this author has apparently not considered it possible for a content to be recognized without the use of a memory image; nor, what is more, has he considered it possible for elementary contents, such as tones, to be recognized without the aid of a memory image of their own kind. This criticism is, I think, justified by a statement on p. 482, when, after having distinguished 'immediate' from 'mediate' (conceptual) memory, he says: "If what we are to remember is some delicate shading of color or some fine variation of pitch, it must be recollected immediately." Bentley's experiments with finely graded visual qualities[3] and our own with finely graded tonal qualities show that recognitory judgments in which there is no memory image of the original stimulus are not only possible but frequent. This same objection to Kennedy's treatment arises as one reads his discussion of the fading of the image (p. 492). He urges that, until possible qualitative and quantitative (intensive, temporal, spatial) variations of the image are excluded, we

[1] The disparity extends also to many of the detailed conditions of experimentation. For example, our use of a number of irregularly placed standard stimuli makes a distinct difference between our tests and those of Martin and Mueller. Thus there is no evidence in our experiments of anything analogous to the judgments passed absolutely upon an isolated weight.

[2] *Psych. Rev.*, V, 1898, 477-499.

[3] See especially pp. 39-40.

cannot be sure that r/n measures this fading. We prefer to say that r/n does not necessarily tell us anything at all about the condition of the image.

In view of this criticism, we fail to see how any amount of tables can furnish data for the plotting of curves of qualitative or quantitative change in the image. The only reliable guide to the transformation of the memory image in time is the careful introspection of the observer himself.[1]

There remain to be mentioned the experiments of Angell and Harwood,[2] which are essentially similar to ours in Part I. They involve a study of the discrimination of tonometer clangs (512-1024 vibs.) under varying conditions of time-interval (1-60 secs.) with reference to the presence and function of the memory image. One-half of the judgments, however, are obtained under conditions of distraction. In their summary of results Angell and Harwood assert that "no law can be laid down in regard to a decrease in accuracy of the so-called tone-memory for intervals up to 60 seconds; the most that can be said is that there is a small and irregular falling off for some [observers] and no falling off for others." On the other hand, there is a very marked falling off in accuracy of judgment with increase of time interval for D=0. This latter finding is, of course, in agreement with Wolfe.

In the second paper (p. 58) Angell discusses the results gained by the use of various distractors: adding, counting metronome beats, reading backwards, listening, and clang discrimination. Their outcome may be gleaned from the following quotation: "The main conclusion to be drawn from the distraction experiments is that judgments of tone discrimination can take place, and in the majority of our experiments did take place, without conscious comparison between the present sensation and a memory image of a past sensation."

One can but regret that Angell did not pay more attention to the introspective evidence. The excuse offered, viz., that too much stress upon the introspection would have invalidated the quantitative results, seems to us to be negatived by the evidence of our own experiments. In the short intervals one can formulate the introspective report entirely by 'post mortem' examination. In the longer intervals the introspection formulates itself in verbal phrases as the test proceeds. Only rarely does this process distract from the decision at the end of the interval. The cases reported read something like this: "Image fluctuated with my breathing. Got thinking about this and lost it." As was natural, this sort of self-consciousness about the experiment occurred most often in the writer's own observations. That it is not a prominent source of error may therefore be inferred from the fact that his right cases exceed in number those of any of the other observers.

[1] For further discussion of these and cognate points in Kennedy's article, see Bentley, *op. cit.*, p. 13.

[2] This *Journal*, XI, Oct., 1898, 67; *ibid.*, XII, Oct., 1900, 58.

CHAPTER I.

EXPERIMENTAL.

The following experiments were conducted in the acoustic room[1] of the Cornell laboratory.

For convenience in discussion and tabulation the course of experimentation is divided into two parts, the second of which is further subdivided into four series. Each section will be treated in general as a distinct line of investigation.

PART I.

The experiments comprised under Part I are in a certain sense a repetition of one of the series published by Wolfe in 1886,[2] but, as we have already pointed out, our purpose is quite different; we wish to trace introspectively the nature and course of the tonal memory image,[3] and to analyze the processes of judgment. For this reason our experiments are fewer in number for each observer, but especial emphasis is laid upon each individual test.

Instrument. All the tones in Part I are given by an Appunn tonometer (512-1,024 vibrations) actuated by the Appunn bellows. A weight of 4.7 kg. upon the main bellows and a weight of 1 kg. upon the lid of the tonometer give satisfactory duration and intensity.[4] On the other hand we have found it very difficult to obtain a sufficient number of series of tones of similar clang tint.[5] The tones finally chosen as standards are 612, 724, 832, 928 and 984 vibrations, denominated *a*, *b*, *c*, *d* and *e* respectively. The difference (D) amounts to 0 or to ± 8 vibs., so that, besides the standards, there are used the reeds giving 604, 620, 716, 732, 824, 840, 920, 928, 976, and 984 vibrations.

The choice of these tones must be made by laborious testing of the whole tonometer. It is obviously important that at least within a given group (N, N+8, N−8)

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[1] This room is not intended to be sound-proof, but it offers distinct advantages for the prosecution of such studies as the present, in view of (1) its isolation by heavy walls from the other parts of the laboratory, (2) its length, which enabled the observers to sit 9 meters from the instrument, where they were not distracted by the noises incident to its manipulation, (3) the adjustable hanging curtains for the elimination of echoes, and (4) the complete electrical connections with other rooms, more especially with the 'registration room,' which enabled chronometric readings to be taken without disturbance to the observers. Practically the only distraction to the experiment came from sounds external to the building. Whenever such distractions were reported the test was thrown out.

[2] *Op. cit.*, especially p. 542.

[3] We include both the memory image proper and the memory after-image. See Fechner, Elemente der Psychophysik, Leipzig, 1889, 2nd ed., II, 468 ff., and Bentley, *op. cit.*, p. 15.

[4] More especially as it is thus unnecessary to operate the bellows during the clang. A single downward thrust of the foot is made simultaneously with the 'ready' signal. This suffices to produce a steady tone of one second's duration beginning two seconds after the signal.

[5] *Cf.* Stumpf and Meyer, *Zeits. f. Psych.*, XVIII, 1898, 330.

the qualitative variation of the stimulus shall predominate, and that the 'color' variation shall be minimal; otherwise there may result a judgment based upon the difference of color and not upon a true qualitative discrimination.

While the groups selected are of uniform color, they do not all furnish exactly the D (8 vibs.) desired.[1] We prefer, however, to use these reeds, since their color is uniform and their deviation from the desired D can be computed and properly distributed in the evaluation of the results.

The computation of the actual differences, *plus* and *minus*, from the five standard tones of the instrument was effected by counting the beats between the standard and the next reed above or below (*i. e.*, 4 vibs.), and then the beats between the latter and the reed supposed to give the D required (8 vibs.). In every case we made four counts of the beats, grouping by fours, and with a stop-watch took the time consumed by 56 beats. In order to avoid the irregularities of intensity which would ensue were one to actuate the reeds by the bellows for so long a time (circa 14 secs.), we applied to the tonometer a compressed air device which furnished a steady and adequate air supply at the proper pressure for over 20 seconds. The results obtained by this method showed the actual D's to be as follows:

D for	$a+$,	7.678 vibs.
D "	$a-$,	7.771 "
D "	$b+$,	8.000 "
D "	$b-$,	6.815 "
D "	$c+$,	8.415 "
D "	$c-$,	8.664 "
D "	$d+$,	8.271 "
D "	$d-$,	8.456 "
D "	$e+$,	10.212 "
D "	$e-$,	7.875 "
Average,		$8.215 \pm .587$ vibs.

Inspection of this list shows that the average D used is 8.215 vibs.; the mean variation, 0.587 vibs.; the average *plus* D is 8.515 vibs.; the average *minus* D, 7.916 vibs. The influence of each particular D on the results will be mentioned later, when the influence of absolute pitch is discussed.

Method of Procedure and General Arrangement of Tests in Part I. During a large part of the experimentation we have found it both economical and entirely feasible to work with three observers at each sitting of one hour weekly. The observers are isolated from one another by large cardboard screens, and provided with prepared blanks upon which they record at the end of each test, their judgment, – equal (=), plus (+), minus (—), or doubtful (?),[2] – their certainty, and detailed introspection as to the course of the image and the process of judgment.

The experimenter gives the usual 'ready' signal two seconds before the first or standard stimulus (N).

For the determination of the length of the intervals and of the tones there is fastened to the framework of the bellows immediately behind the tonometer, an upright provided with a horizontal arm from which hangs a simple pendulum. This pendulum consists merely of a thread and lead bob so adjusted as to swing in seconds. We prefer, for various reasons, a silent metronome of this sort to the ticking metronome employed by Wolfe.

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[1] Stumpf and Meyer, *loc. cit.* p. 327.

[2] In the second half of the experimentation, doubtful tests are repeated until the observer makes satisfactory judgment, but the number and distribution of these cases are recorded.

After waiting for an interval of 2, 4, 6, 10, 15, 20, 30, 40, or 60 seconds, the experimenter gives the variable or comparison stimulus (V), which is either the same as N (D=0), or higher (D=+8), or lower (D=—8). No ready signal is given before V, even in the long intervals. The reasons for this are: first, that the *speaking* of a 'ready' or 'now' at the end of the interval, when the subject is attending 'with might and main' to the memory image, proves to be a distraction rather than a help; while, secondly, the slight but unavoidable noise of pumping the bellows for V, which the experimenter soon comes to produce quite uniformly and at a constant time before V, affords an entirely adequate and yet unobtrusive signal for the attention of the subject to the second tone. Both stimuli last one second, as nearly as the operator can manipulate the stops in time to the swing of the silent metronome.

The further arrangements of the tests of Part I may be summarized as follows. In each hour of experimenting, each observer is given each one of the standard tones, *a*, *b*, *c*, *d*, *e*, three times; once followed by V=N, once by V=N+8 vibs., once by V=N—8 vibs. The order is, of course, quite irregular, though the same for each observer in a given test, and care is taken that the same N is never given twice in succession; for our preliminary tests show that many observers, even after spending two or three minutes in writing their introspection, are able to identify a repeated N as identical with that of the preceding test.[1]

Several weeks were given to preliminary determinations[2] both for the sake of practicing the observers and in order to settle upon favorable detailed conditions of procedure. After this practice period, to the results of which we shall make incidental reference, the experiments proper of Part I began.

Part I is practically subdivided in point of time into a first and a second half. In the first half the intervals (time elapsing between N and V) are taken up in the order 2, 60, 4, 40, 6, 30, 10, 20, 15; in the second half exactly the reverse order is maintained. The object of this arrangement is to distribute as evenly as possible whatever practice effects might persist after the termination of the preliminary period especially designed to familiarize the observers with the work. The results later to be discussed show that the practice curve does gradually rise during at least the first half of Part I.

It is obvious that the number of tests for each interval is

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[1] The extent to which the constant use of one or a very few standards may affect the observer's judgments is well exhibited in the analyses of Martin and Müller, *op. cit.*, 43 ff.

[2] These include tests with 4 and 8 vibs. D at 10 and 20 secs. interval, and tests of distractors, especially reading.

doubled by the arrangement just mentioned. Accordingly each of the six observers passes 15×2, 30 judgments upon each one of the nine intervals, so that the total number of tests represented in Part I, for all subjects and all intervals, is 1,620. The number of cases for each time-interval, 180, is relatively small as compared with the enormous number of tests which many investigators have employed when working by the method of right and wrong cases, but we do not wish to place any high degree of insistence upon the generalizations which we shall base upon purely quantitative results, since our immediate purpose is analytic. We are interested rather in the structure of the conscious processes which run their course during the time-interval and during the formation and expression, whether by word of mouth or reaction movement, of the judgment which terminates each test. We insist that, from this point of view, mere numbers are not an essential to the legitimate conduct of the psychological experiment; on the contrary, given the proper, the optimal conditions (of practice, attention, etc.), each test which includes the careful introspection of a trained observer has a right to demand for itself a hearing, to be regarded as a datum. Every such test counts for one experiment.

Subjects. The subjects in the experiments of Part I are all students in Cornell University who have had training both in general psychology and in the introspection of laboratory drill work. Since the investigation of any such problem in acoustics as the one here presented must take into account, in a rather detailed manner, the musical training of the persons concerned, it seems too vague to classify the subjects roughly as 'musical' or 'unmusical'; hence there follows a brief 'musical history' of the six subjects who participated in Part I.

1. *M.* (Miss M. F. McClure), a few piano lessons; has studied harmony; a slight acquaintance with the banjo and mandolin; sings alto or low soprano parts; carries airs very easily; generally fond of music, especially of church-organ or orchestral effects, which often incite brilliant photisms.[1] Introspection painstaking and detailed, but liable to be influenced at times by suggestion. Generally alert mentally.

2. *W.* (Mr. J. H. Wilson). Non-musical family; no lessons in singing or upon any musical instrument; very fond of music; prefers piano to any single instrument, the orchestra to the brass band; whistles and hums popular airs a great deal. Despite certain of these indications *W* must be classed as strictly unmusical, as will be shown by many features of his introspection. Unfortunately his absence during the second year of experimentation forestalled a series of subsidiary tests which had been planned to elucidate some of his peculiarities. Tendency to retain N by aid of articulation.[2] Very slow and cautious in judgment; of a distinctly phlegmatic type.

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[1] For a detailed account of the photisms and allied phenomena of *M*, see this *Journal*, X, 1900, 318.

[2] Actual articulation or humming was, of course, excluded.

3. *S.* (Miss Claire Seymour). Unmusical, as were her parents; piano lessons when from 12 to 15 years old, including moderately difficult selections, but these were invariably acquired by committing to memory the appropriate keys; cannot recall at will more than a dozen notes of any selection however many times it has been heard. One term singing lessons; sings soprano, but only when in a loud chorus and 'carried along' by the others. Very fond of music; prefers church organ, orchestra, and male voices. Strong liking for all low tones on account of their fullness and *cool* soothing character. When a child, emotional, thrilling music,—especially that in which low tones predominated,—aroused photisms which formed quite an important mental feature for about two years. Early in the course of these experiments *S* developed visualizations which came to be uniformly present, and which at times served as a basis for judgment. These will be discussed later. *S*, as above mentioned, also associated temperatures with tones. High tones were warm and unpleasant, low tones cool and pleasant (like the bathing of hands and face in cool water). Tests of *S*'s photisms revealed nothing worthy of detailed mention. Introspection good, though occasionally restricted by a spirit of competition; *S* worried to think other observers might be getting more right cases.

4. *F.* (Mr. H. H. Foster). Distinctly musical. Training: the usual vocal instruction in public schools supplemented by about six years private lessons. Voice, bass (*E* to *e'*); uses solmization. Occasional obsessions of 'tunes in the head.' Plays violin often, piano less often. Strong tendency to fix the pitch of N by humming. Introspection quite good, but of a general sort, lacking finer details; constitutionally tired.

5. *L.* (Mr. E. T. Lies). Mother musical; father fond of music, but not a musician. *L* took piano and organ lessons for eight years; early taught to sing; has done a large amount of singing in choirs and choruses, for a time being organist and chorister. Voice baritone (*G* to *d'*). Cannot commit to memory easily; prefers orchestral music in general, and always harmonic music to solos of any sort. Frequent obsessions of 'tunes in the head,' mostly instrumental music; a single selection is apt to prevail for one or two days. Introspection rather scanty, stereotyped, and subject to logical bias, *e. g.*, that judgment was impossible without conscious comparison.

6. *Wh.* (the writer).[1] Distinctly musical; plays piano, banjo, mandolin and guitar; sings baritone; has had vocal instruction. Auditory imagery generally prominent; centrally excited tonal imagery, both vocal and instrumental, melodic and harmonic, very prevalent, especially when incited by any sort of rhythmic action, such as walking or eating. The presence of so much auditory imagery is, as might be expected, the correlate of a well developed capacity to reproduce all sorts of music at will. From continual service as experimenter as well as observer, *Wh* naturally obtained a very high degree of practice. There is no vestige of memory for absolute pitch.

(To translate this classification of the subjects for comparison with the German standards, we should say that *W* and *S* are hopelessly 'unmusikalisch;' *M* is also strictly speaking 'unmusikalisch,' though possibly ranking as 'wenig musikalisch.' *L*, *F*, and *Wh* would be 'musikalisch' in any German monograph, but they have perhaps none of them been favored with so many opportunities to listen to good music as would be implied by the connotation of the German adjective.)

Results of Part I. It follows, both from the general object and nature of these researches, as well as from the wide variation of the capacities of the observers to image tones, that the general crude results of the experiments are of relatively less importance than the more distinctly analytic data which we shall present for the most part under the heading "dependence upon the individual." Yet the individual variations must be

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[1] Our thanks are due to Mr. W. B. Secor for serving as operator for *Wh.* during Part I, and to Dr. W. C. Bagley for a similar service in Part II.

discussed in the light of the general and average results, and, moreover, despite the smaller number of cases, we believe that the numerical results are worthy of consideration as regards their relation to the Tables obtained under similar conditions by Wolfe and by Angell and Harwood.

TABLE I.* *(1620 tests.)*

Inter-val.	D = 0			D = + 8			D = — 8			Doubt-ful.	Total right cases.
	r	+	—	*r*	=	—	*r*	=	+		
2	51	6	3	39	8	13	40	8	12	0	130
4	48	6	6	43	10	7	35	15	9	1	126
6	45	6	9	42	9	9	32	20	8	0	119
10	45	7	8	39	10	10	38	17	5	1	122
15	49	6	5	42	6	12	37	14	9	0	128
20	40	14	6	38	14	8	31	17	11	1	109
30	30	20	10	37	14	9	34	18	8	0	101
40	34	9	16	31	20	8	40	11	9	2	105
60	29	12	19	32	12	14	36	14	8	4	97
Total,	371	86	82	343	103	90	323	134	79	9	1037

**r* denotes the number of right cases, + the judgment 'higher,' — the judgment 'lower,' and = the judgment 'equal.' The nine doubtful cases are, for convenience, given in a single column. For their distribution, see below.

Table I gives the distribution of the judgments of all six observers for the tests of Part I. Attention is called to the following numerical features:

1. The right cases:

(*a*) *Increase of time-interval causes a general decrease in the total number of right cases. At two points, however (15 and 40 seconds), the curve is peaked.*

(*b*) *Both the general decrease and the two points of resurgence in the total number of right cases are traceable practically to the results for D=o alone.*

(*c*) *Increase of time-interval effects a very slight but fairly uniform decrease in the right cases for D=+8.*

(*d*) *Increase of time-interval has practically no effect upon the number of right cases for D=—8.*

The fact that the cases for D=o suffer most as time elapses is in accord with the results both of Wolfe and of Angell and Harwood. The rise in this curve at 15 and 40 seconds appears to corroborate strongly Wolfe's contention for a periodic renewal of the tonal memory image. We shall see how further analysis of the results bears out this hypothesis.

(*e*) *The total number of right cases is greatest for D=o, less for D=+8, least for D=—8.*[1] A similar result is reported by

[1] The precedence which D=+8 takes over D=—8 may possibly be

Wolfe (p. 556). We may be inclined to doubt, however, whether this fact signifies that judgments are passed with any greater accuracy and confidence when $D=0$. For, leaving introspective evidence out of account, the Table shows that, with $D=\pm 8$, the most frequent error is the judgment 'equal.' We may, therefore, suspect that there exists a general tendency to give this decision in certain conditions of doubt,—conditions in which the degree of uncertainty is not sufficient to cut off the process of judgment entirely, *i. e.*, not sufficient to be actually registered as 'doubtful.' From data to be presented later, we find that of the correct judgments of 'equal' and 'higher,' the same percentage, 76, are certain: only 66 per cent. of the correct 'lower' judgments are also certain.

2. *The errors.*

(*a*) *The errors in the order of their frequency are* $-=$,[1] $+=$, $+-$, $=+$, $=-$, $-+$: *the last four in nearly the same frequency.* We have just remarked upon the relatively great frequency of the first two errors, due to the tendency to pronounce two impressions alike when the difference between them is not clearly made out. We shall see the force of this point when we discuss the introspection of the subjects.

(*b*) *The frequency of the error* $=-$ *increases nearly uniformly with the time-interval employed. It is the smallest source of error at 2 seconds, the greatest at 60.* It is very difficult to see how this fact could be explained by Wolfe's theory[2] that the memory image, as it declines in intensity and clearness, is underestimated in pitch. Now it is true that our total $=+$ error is 86 as against 82 for $=-$, but the former error exhibits no gradual increase with time, although it is entirely reasonable to suppose[3] that increase of the time-interval would emphasize gradually any such error of underestimation. The possible solution that the observers, fearing that the image was flatting as well as losing in intensity, made, as time passed, an increasingly strong effort to hold it to pitch, and thereby actually sharped it, is shown by our tests to be the true solution in the case of some observers.

(*c*) *The error* $+-$ *is somewhat more common than the error* $-+$; *neither is noticeably affected by the lapse of time.*

3. *The nine doubtful cases* are contributed one each from *M*,

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ascribed to the fact that, as is pointed out above (p. —), the average *plus* D is really greater than the average *minus* D. Wolfe assigns the precedence to underestimation of the image.

[1] That is, the judgment 'equal' is given when D is -8, etc. When $=$ precedes, it means that $V=N$, *i. e.*, $D=0$ is given.

[2] *Op. cit.*, p. 556.

[3] Wolfe's Table (p. 562) unfortunately does not show the distribution of errors by time-interval.

W, and *S*, two from *L*, and four from *F*, the standards being once *e*, twice *c*, and six times *d*. There are 14 doubtful cases in the second half, not indicated in Table I,[1] one from *F*, four from *L*, nine from *S*. Then the standards were three times *a*, once *b*, once *c*, six times *d*, and three times *e*.

4. Dependence upon practice. By comparing the results of the first and second half of the work which is represented *in toto* by Table I, it can be shown that, despite the preliminary period designed to familiarize the observers with the experiments, practice does lessen the total number of errors of each type (save that of $+=$, which is increased in the second half of the year's experimentation). The error $+-$ is reduced nearly one-half. The total number of right cases is increased for every interval except 20 seconds. This exception is due to extraneous conditions, being directly traceable to the fact that, on the second occasion of this test, one observer was "very hungry," another "tired, cross and sleepy." The practice effect is almost entirely confined to the unmusical observers,[2] thus, the total number of right cases for *M*, *W* and *S* increases from 198 in the first half to 238 in the second, *i. e.*, about 20%; whereas the total number of right cases for *F*, *L* and *Wh* increases only from 298 to 303, *i. e.*, less than 2%. There is no uniformity as regards the nature of the improvement. The chief gain during the second half is for *M*, with $D=+8$; for *W*, with $D=0$; for *S*, *F* and *Wh*, with $D=-8$ (*F*, by decreasing the error $-=$, *S* and *Wh* by decreasing both the errors, $-=$ and $-+$). *L* shows no practice effect; on the contrary, he loses ground slightly for every type of D. We believe that in so far as regularity of quantitative results is desired, it would be advisable to train unmusical subjects by systematic coaching in *sensible* discrimination; *i. e.*, by a series of preliminary tests in which any erroneous judgment is immediately corrected.[3] We did not adopt this course, because it threatened to interfere with the natural development of the judgment consciousness which it was desired to observe.

5. Dependence upon absolute pitch. Within the octave employed (512 to 1,024 vibs.) there is no observable dependence upon pitch. This is clear from a glance at the 'total' column of Table II. It is more difficult to assign the effect of the variations in the various values of D from the 8 vibs. theoretically given (see p. 417). Apparently the low value of *b*— (6.815 vibs.) does diminish the number of right cases, for in 108 trials it is correctly judged but 52 times; and, what is more

[1] See footnote p. 417.
[2] C. Stumpf: Tonpsychologie, I, 321.
[3] On the effect of such a training by the method of partial knowledge, see Martin u. Müller, *op. cit.*, 195-6.

TABLE II.

(*Right cases by pitches.* (*108 cases each.*)

STANDARD.	D=0.	D=+8	D=−8.	TOTAL.
a	69	82	69	220
b	77	77	52	206
c	81	60	65	206
d	66	54	69	189[1]
e	78	70	68	216
Average,	74.2	68.6	64.6	207.4

significant, the error −= is recorded 40 times, that of −+ but 16. In other words, the uncommonly small objective value of D in this instance favors the judgment 'equal.' On the other hand, the rather large D in the case of $e+$ (10.212 vibs.) does not increase the number of right cases: there are even 12 more right cases with $a+$ (7.668 vibs.) than with $e+$.

6. *Dependence upon the individual,—the introspection.* The individual variations in the numerical results can be properly understood only in the light of the introspective data, for the variations in the methods of judgment and capacities for retention of different observers lead to widely divergent results under different conditions of experimentation. We shall, therefore, consider in this place not only the quantitative dependence of the results upon the individual observer, but also those questions which can be answered only by the aid of introspection. The two chief questions are: (1) what is the nature and the course of the tonal memory image, and (2) what is the nature of the judgment process?

In order to facilitate the introspection generally, to avoid stereotyping, and to direct the attention upon all the points at issue, a placard containing a full list of these points was hung before the observers, and they were requested to glance over it from time to time between the tests. We believe that the wide range of the topics thus presented accomplished the object intended without introducing the error of 'suggesting' any particular introspective verdict whatsoever. The card read as follows: Image: beginning, timbre, localization, constancy (pitch, intensity, clearness), muscular strains, associations (colors, words, etc.), attention strains. Judgment: time, certainty, terms (tonal, verbal, muscular, affective, spatial). It was, of course, not to be supposed that any large number of these points could be noted in a single introspective report, but they could all be noted in the course of three or four tests. Further, during the larger part of the experimentation, a consultation was held with each observer immediately at the close of the hour's work: his reports were carefully examined, and he was questioned upon the obscure details. Here, also, the utmost care had to be used to coach the observers without 'suggesting' the results to be found. Thus, after hinting at the possibility of a purely 'verbal' type of judgment, *M* reported eight of this sort in the next set of 15. Suggestibility of this kind must be met by counter-suggestion. Three general sources of difficulty were encountered in the early course of the investigation, but they were successfully eradicated. These were (1) a tendency to stop to introspect during the time-interval, (2) a tendency to too long after-introspection, and (3) a tendency to anticipate the relation of the coming V to N, *e.g.*, "This will be '*plus*.'"

[1] Compare the large number of doubtful cases with *d*, p. 423.

A. The Memory Image.

Observer M.

The following propositions may be laid down concerning the origin and course of the image in the case of *M:*

1. The standard (N) usually arouses either (*a*) photisms,[1] (*b*) strain sensations, or (*c*) associations (commonly personifications).

Examples are: (*a*) purple, dark rich blue, thin steely blue, horrid yellowish green, "darkness of the field stirred." (*b*) "Both tones seemed to be felt in brows." "N high and thin: strain in my head as if trying to reach it." (*c*) "Far away as if coming through a fog." "Like a tall, well-built woman with dark hair and clean-cut features."[2] "Made me cross, like a gruff, disagreeable old man." "Sharp like a butcher's knife" (visualized). "Extremely smooth and pleasant like a still pond in warm sunshine in summer."

2. After the cessation of N there is a short interval (about one second) devoid of auditory filling. The image then "emerges."

3. The image is almost invariably of the timbre of the tonometer.

The three exceptions noted are: "Image in terms of my voice supported by movement and strain in throat." "Effort to remember N by translating it from tone of instrument to tone of my own voice; strain in throat."[3] "Image had timbre of instrument and my voice."

4. The image is localized (*a*) commonly at the back of the room, *i. e.*, at the actual source of sound; (*b*) very frequently, however, somewhere in the head; (*c*) occasionally, N seems to affect one ear only, and then the image is apt to be localized there.

Illustrations: "Through middle of head." "Just above eyes, inside." "In ears: thought of ears when trying hard to recall it." "N especially strong in right ear, and image rang in right ear all the time. The memory of N seemed to be all in the right side of my head." "N filled both ears as a cork would fill a bottle. I felt as a bottle must when the cork is put in."

5. Variation in the image.

(*a*) Qualitative variation is but once noted.

"During the interval an 'after-image' of the tone of the previous test returned, and I got mixed up, but at V the real image of this test appeared." A quasi-qualitative shift is thus indicated: "Image almost lost once, but recalled by slight muscular strain and visual aid (eye feeling as if it were going down the scale and running over two or three notes as it neared, passed and returned to the right note)."

(*b*). (1) Variation in intensity ('fluctuation') is first noted in the six-second interval; it is quite common at 10 seconds. (2) From two to four fluctuations (periodic increase and decrease of intensity) are recorded at 10 seconds, from four to seven at 20 seconds, etc. (3) At

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[1] *M* was seated before a window screened by a yellowish green shade, so that the closing of the eyes for each test may have induced a positive or negative after-image which suggested these photisms. The colors observed are, however, too varied in quality and too uniform in their temporal connection with N to be fully explained in this way. While the color clouds rarely play any part in the judgment, other visualizations do so. At times V arouses a photism different from that of N. For a detailed investigation of *M*'s photisms, see this *Journal*, XI, 1900, 377 ff.

[2] In this instance V had the same 'feeling,' and the judgment was based upon these associations.

[3] Here the judgment was made "by throat and vocal feeling."

with the two-seconds interval there is frequently no image during this time.

A curious filling of the image-less gap is once reported: "At cessation of N, I heard the operator say 'ready,' visualized him pulling the stop, then the image appeared," *i. e.*, the image appeared only after a recapitulation of the whole experience of its production.

3. The image is always of the timbre of the tonometer.

4. The location of the image is invariably at the back of the room, and is often maintained there by the visualization of the instrument, as above mentioned.

5. Variation in the image.

(*a*). Qualitative variation is but once reported, and in this case there is rather uncertainty from the beginning than a shift during the period.

"Did n't get first tone well in mind. I had an argument with myself whether it was a certain tone or not, and then I got more and more certain of it as time went on. I used the image in the judgment" (which was incorrect).

(*b*). (1) Variation in intensity appears as soon as an image appears, *i. e.*, in the four-second interval. (2) The image may be entirely gone at the end of the six-second interval. (3) Image-less gaps of five seconds duration are reported in the 30 second interval. (4) At 40 and 60 seconds images are almost always said to be present,[1] but the greater part of them are rated as 'bad.' (5) Attention strains appear at 10 seconds, and are characteristic of all intervals longer than that.

"Held breath to keep image." "Great frowning to hold image." "Tendency to produce sound in my throat when I wanted to bring back image." "Fluctuation seemed to go about with my breathing."

(*c*). Two cases of shift in clearness appear to refer to an illusory bettering of the image with time.

"After a period of fluctuation, image seemed to get clearer, more distinct." (40 secs.).

6. Relation of the image to N and V.

(*a*). V often (1) dispels the image, but (2) more frequently it 'recalls' it.

"Second tone broke up the image." The recall is noted, *e. g.*, in the two seconds interval when no image had formed. Here the sounding of V is said to make an image of N appear. The recall is also noted very frequently in the long intervals when the image has practically disappeared in the meantime. The excellence of a 'bad' (during the interval) image which is recalled at the end of 60 seconds by the variable tone may be questioned. How shall we estimate, for example, the value of the use of the image thus described: "Had an image of the tone pretty well at first, but it fluctuated and I could hear only the high part of it, and could not tell its timbre until I heard V. Then I remembered about how N sounded, and made a judgment by comparing the two tones?" This instance bears out our previous supposition,[1] for it leads one to suppose that the auditory elements ("timbre") of the

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[1] There is reason to believe, as will be shown later, that W overrates the excellence of his images in these cases, and that he may consider an image to be present when there is little or no trace of the auditory core, but perhaps simply an organic complex, strain in throat, forehead, etc.

original complex have disappeared, while the organic or strain sensations ("the high part of it") remain and are attended to as the image.

Observer S.

1. N usually arouses either (*a*) photisms,[1] (*b*) pleasantness or unpleasantness, or (*c*) associations (largely of visualized geometrical forms, less often personifications).

Examples are: (*a*) heliotrope, pale green, reddish brown, yellow line on a dark background. (*b*) "Low and strong and pleasant." Low tones are uniformly pleasant, high ones mostly unpleasant. (*c*) "Like two curved lines or rather what was contained between them; much clearer in center and growing fainter along edges." "Soothing like cool water, and more like a round ball than a line." "Image seemed like a woman, perhaps a woman's voice." "Visualized a boy blowing a 'squawker,' quite amused."[2]

2. There is always an interval without any auditory filling immediately after N. Its length is variously estimated from a fraction of a second to three seconds, usually at two seconds.

3. The image almost always has the timbre of the instrument.

Once it "seemed in terms of a horn" (with visualization of the brass mouth of a horn). It should be remembered that *S* usually carries over into the image those phenomena which are aroused at N, so that it would be, perhaps, misleading to describe the image as a merely auditory representation of the clang, *e. g.*, "the image had something spatial about it which grew larger and smaller each time the auditory part fluctuated." Similar illustrations are given later.

4. The location of the image is either (*a*) in space in front of the head;[3] (*b*) somewhere within the head, or (*c*) very rarely, close to the head, but behind it.

(*a*) "Outside on a level with my forehead, having thus a location but no form." (*b*) "Felt in throat." "In ear and head." The following is a peculiar combination of (*a*) and (*b*) which is frequent. "Auditory image within my head, but at same time a spatial position for it outside." (*c*) "Back, behind left ear."

5. Variation in the image.

(*a*) Qualitative variation is extremely frequent with *S*, the variation being in every case declared a flatting in pitch.

"Image fluctuated with breathing, and flatted slightly. Did not attempt to bolster it up, simply recognized that it was too low and made allowances in the judgment." (D = —8 given; judgment 'equal.') "Pitch fluctuated a little, but I managed to bolster it up just before V came." (Judgment correct.) A quasi-qualitative varia-

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[1] Unlike *M*, *S* makes these ascriptions with considerable constancy, *e. g.*, standard *a* is nearly always heliotrope; *b* is green, etc. On the other hand, *S* does not experience photisms outside of these tests. She does occasionally make use of them in the judgment process.

[2] These associations are obviously, like the photisms, determined by the general organic reaction or affective result of the standard. Like the photisms, too, they exhibit rather remarkable constancy, so that, while totally unable to identify the five standards tonally, *S* did possess a rough knowledge of the identity of the standard by dint of these associations, thus, standard *a* is always strong, cool, round or heliotrope. It must be added that this rough classification of the five tones did not avail in making the finer discriminations required in the tests, with the exception of the instances to be found below.

[3] When the relation of V to N is based upon 'spatial' relations, V is placed with reference to this situation of the image.

tion in quality occurs once. "Image seemed alive and trying to baffle me. I became very angry and determined to get ahead of it. It danced up and down, to and fro, and I tried to make it keep the place assigned to it."

(*b*). (1) Fluctuation in intensity, even entailing complete disappearance of the image is reported at four seconds interval, and is characteristic of all longer intervals, though the image-less gaps are not common till the intervals of 15 seconds and longer. (2) The fluctuations may be regular, coincident with breathing, or quite irregular. (3) The support of the image by various muscular strains begins at the two-seconds interval, and is a feature of all the other periods. (But see below, 6).

"Held breath throughout interval" (two seconds). "Contraction in my throat, as if getting the pitch by singing, seem to steady the image." "Great strain around eyes to retain image." "Shook my head to keep out distracting thoughts." "Image disappears when I exhale. I sometimes 'catch' it by inhaling quickly and holding my breath."

(4) The auditory image may fluctuate independently of its visual and other concomitants, or they may vary together.

"Image spatial and auditory. Took a definite position and stayed there, though the auditory image often faded away completely." "The spatial setting of the image grew larger and smaller each time the auditory element varied."

(*c*). Variation in clearness is rarely noted, with the exception of obscurations of pitch, when a tendency to flat is suspected.

6. Relation of the image to V.

(*a*) The sounding of V (1) usually recalls the image; rarely it (2) exercises an unfavorable effect upon it.

(1) "Nearly lost image, but it came back all right after V ceased." A rather peculiar recovery, in which the reliability of the image thus gained may be doubted, is the following: "Lost image entirely after about three seconds, and did not recover it again till after V had come. All through the interval I sat relaxed, but confident that the image would come back." (30 seconds, D = − 8, judgment '*higher*'). (2) "Retained image, but was unable to decide between 'plus' or 'equal' because I lost the image too soon after V sounded to be able to compare."

Observer F.

1. The standard never arouses associative phenomena; there is only an occasional unpleasantness at 'reedy' clangs.

2. No mention is made of an interval after N free from an image, but the image is said to be weak just after N, then "budding out."

3. The timbre of the image is indifferently that of the tonometer or vocal. *F* says he can think tones vocally beyond the range of his voice.

4. The localization is usually in the left ear, less often within the head, occasionally over the tonometer or directly in front; it may shift during the interval.

"Vaguely somewhere on the wall." "Location in head through the interval, then, expecting V, it changed to my left ear."

5. Variation in the image.

(*a*) Qualitative variation is very common, and always in the form of a tendency to flat.

"Tendency to flat resisted by effort. Tendency caused by the presence of a number of lower tonal images in my mind." "Image flatted at least half an octave; it was a vocal image varying with the position of my mouth, throat, etc." "Attempted to replace the lost image by 'sliding the scale;' thought I recognized it when I came to it." "The tendency of the pitch to flat was marked by a feeling that the muscles of the head were being relaxed."

(*b*) A curious but frequent report was that of the presence of an "unconscious tone." This may be interpreted as an 'organic set' of some sort.[1]

We shall see later that *F*'s judgments abound in 'motor' elements. The "unconscious tone" is the persistence in consciousness of the 'feel' of the place of the tone when all auditory features are lacking. "Image good for half the interval (40 secs.); then while the image seemed to last, no tone was to be found." "Image seemed to lapse before V, yet the sense of strain in my left ear continued, being increased at V." (Judgment *plus*, correct.)

(*b*) *F*'s images were for the most part of but "fair" strength. They tended to fluctuate irregularly, and in intervals beyond 10 seconds to lapse entirely for considerable lengths of time. They were replaced by "will power" generally, though sometimes this is analyzed into "strains in the throat," especially if the image be of vocal timbre.

(*c*) The image was very often vague even when of fair intensity. Clean-cut images were the exception at all intervals.

6. Relation of the image to V.

A lost image may return at the sound of the bellows before V. More often the sounding of V causes the image to disappear.

"Image crowded out of consciousness by turning the attention to V." In one series *F* contracted the habit of letting the image go into "passive attention," in order to have his "active attention" ready for the coming stimulus.

Observer L.

1. N causes strain and pressure sensations about the head, affective reactions or associations.

Low tones are uniformly pleasant, and are further described as big, round, filling the ear passages; high tones are uniformly unpleasant, hin, penetrating. There are two instances of visualization: "After was given, a picture of the tonometer and of a musical reed came p, and I saw the sound come from a reed in the box." "N aroused a sual-auditory ideas of a long, lanky 'co-ed' with a voice like this mulus, thin and 'smudgy.'" Verbal associations are: "Like the und of the letter *l*." "Like the sound *il* made in the upper and ck part of the mouth by a female voice." The strain and pressure sations (probably contraction of scalp and ear-adjusting muscles perhaps changes in blood supply) are illustrated thus: "N prod an expansive effect within the head as if something were inside

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he 'organic set' of *W*, the introspections of *S*, 5 (*b*) 4, and the tone-less image

trying to force out the forehead." "N produced a quiver of sensation around and above each ear."

2. No mention is made of an imageless gap directly after N.

3. The timbre of the image is either that of the tonometer or of *L*'s own voice, natural or falsetto.

(Standard *a* is said several times to be so low as to be imaged in terms of his natural voice, but this is obviously impossible since its frequency is 612 vibs.) Images beginning in the reed timbre usually become vocal if a strong effort is made to hold them in consciousness.

4. The image is variously localized, in the head, in both ears, just outside the ear, at the tonomoter, or nowhere.

The localizations at the tonometer have some significance because the standards are placed there in strata, *a* being invariably near the floor, *e* being invariably near the ceiling, the other clangs disposed with less exactness between these two. As will be seen, this spacing plays a subsidiary part in the judgment consciousness. *L* occasionally converts intensity into distance, *i. e.*, a "waning" image seems "to wander off, far away."

5. Variation in the image.

(*a*). Qualitative variation is but three times mentioned, always taking the form of a tendency to flat.

(*b*). L's images are reported to be exceptionally good.[1] Fluctuation is not reported until the 20 second interval. At 30 seconds the waning of the image is quite noticeable, but it rarely goes entirely, and can be recovered by imagining it as hummed by the voice. Even at 40 seconds the image may persist through the interval without active effort to retain it.

(*c*). Obscuration was not differentiated from lessened intensity.

Observer Wh.

1. At N the breath is held; associations, always auditory-verbal, are often aroused, and, with certain high notes, aural sensations, described as a sort of reflex pull, are prominent. At the sounding of the bellows for V there is a "peculiar feeling of excitement and expectation all over," and a tendency to call up the image as vividly as possible.

Examples are: standard *e*: "Verbal association, 'peep,' clear, piping, pleasant, easy to keep as an image."[2] Standard *a*, "A nasal, 'blowy,' clang: thought of my nose."[2] "Verbal, 'that's *a*.'"

2. The image "wells up" or forms itself at from ½ to 2 seconds after the cessation of N.

3. The prevailing timbre is that of the tonometer, but it may be vocal, or part vocal and part tonometer, and it may shift during an interval.

"Kept image clear aud steady by making it vocal timbre, not actually

[1] Obviously these estimates are based upon a subjective standard of excellence. It seems likely, for instance, that *L* overestimates, while *F* underestimates, the worth of his images.

[2] It is of interest to note that this preference for *e* and distaste for *a* are exactly opposite to the attitude of *L*.

vocalizing, but hearing a purely centrally-excited humming or falsetto tone." "Image usually tonometer timbre now, but it has a number of vocal associations tacked on to it, *e. g.*, contractions of the pharynx, alterations of expiration, localization in the throat, though all these are frequently only imaged, not carried out peripherally." "Started vocal; changed it arbitrarily to tonometer." "Images of a clear, penetrating timbre are easily held."

4. The image is usually localized at the tonometer; it may also be in the head, throat, ear or nowhere. By attention it may be placed almost anywhere. Often its location suddenly shifts when V sounds.

"Image was at the tonometer, held there by purposed visualization of the instrument.[1] At V, or at the sound of the bellows for V, it shifted to my throat, and V placed itself outside my head higher up. V seems to belong outside because it is peripherally excited, and higher because it is higher tonally.

5. Variation of the image.

(*a*). Qualitative. *Wh* exhibits two peculiar phenomena of a qualitative nature, the feeling of a "tone-less" image, and the presence of two or more rival tonal images during the interval. The latter occurrence is extremely frequent, almost the rule in the long intervals. The general tendency of the image is to sharp rather than flat.[2]

"Several times during the interval, I thought I had the image, but there was only an 'organic tone,' a throat contraction and an altered breathing, etc., without any auditory elements. I kept thinking something which swelled up and gradually died out at regular intervals but it was not tonal." "At about six seconds a lower tone, separated from my image by quite an interval, appeared and bothered me." "Several other pitches presented themselves as candidates. I got disgusted, dropped them all, and made the decision without any image." "During interval, I heard repeated several times a little melody of three notes. Two came with each inspiration, and one, longest and strongest, the image proper, with each expiration. The last was coincident with V, so judged '*equal*' easily." "Lost my image, so ran up and down the scale: a certain quality seemed most familiar, so I imaged that, and made judgment easily" (and correctly).[3] "Two images after about the 4th second, the new one was higher and seemed to be suggested by an apparent rise in N as it was shut off."[4]

(*b*) Intensive. As reported, *Wh*'s images rank in intensity between those of *F* and *L*. At two seconds the image is faint,[5] not having had

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[1] Reference to the tonometer is a very frequent device with *Wh* to artificially "force" the image, *e. g.*, "Got twice a very strong, hallucinatory image by thinking of blowing the tonometer very forcibly."

[2] This tendency is found in such introspective verdicts, as, "V way below my image." It is further amply borne out by the numerical tables which indicate that in the intervals of 30, 40, and 60 seconds, *Wh* has a strong tendency to err in the direction which presupposes a sharpening of the image, provided the image is used in the judgment. In conjunction with *F*'s tendency to flat the image, as shown both by his introspection and his numerical results, this individual difference shows the futility of such generalizations as that of Wolfe when he takes it for granted that the image, because of its weakness, will be constantly underestimated in pitch. We do not wish to imply, however, that the qualitative status of the image necessarily influences the decision at all. *Wh*, for example, often gave such reports as, "V was way below my image, yet I felt compelled to judge 'equal' on account of some feeling of familiarity." [Correct.]

[3] The usefulness of an image thus secured in making a discrimination of 8 vibrations after an interval of 40 seconds is clearly questionable.

[4] Compare a similar effect with the bottle tones later mentioned. The rise, at [illegible] here, is subjective, as subsequent tests demonstrated.

[5] *Wh* suggests that the seeming faintness, which amounts sometimes to absence of image, may be due to the fact that since, in this interval, it is so near N and the image suffers from contrast.

time to fully "mature." At four seconds it is steady after it has matured, and does not need to be actively forced. At six seconds general attention strains appear, composed of sensations set up by contraction of the pharynx, of the arms, and by alterations in breathing which is irregular and shallow. There may be a gap without image.

"Heard image sound, stop, start, etc., twice, an exact repetition of the sounding of N."

No image persists through 10 seconds without fluctuation. Usually there are either two or three waves or periods of intensity, the image being strengthened at each expiration.[1] Keen attention to N is a prerequisite for a good image for this period. At 30 seconds, the image is precarious, it suffers from the slightest distraction, central or peripheral, demands urgent attention, is subject to lapses and to qualitative obscuration by the appearance of other pitches. At 40 seconds, it is always unreliable at the end, and usually gone entirely. To hold it in fair intensity for 60 seconds is almost impossible; any relaxation kills it.

(*b*). Clearness. Variations in clearness are indicated closely parallel to those in intensity. The qualitative uncertainty occasioned by the presence of secondary pitches may also be regarded as a loss in clearness. Clearness may be recovered when lost, as well as intensity; *e. g.*:

"Slight uncertainty of pitch for a while, then it cleared up" (15 secs.). "Got clearer toward the end of the interval" (6 secs.).

Several times artificial devices are used to enhance the clearness, *e. g*:

"At about the tenth second, I tried to see if I had the image clearly by imaging a lower tone as if on the tonometer, and seeing if I could tell the difference. I wanted to make sure that the image had some determinateness."

6. Relation of the image to N. A good image depends on keen attention to N. If for any reason, N is somewhat faint, the image may yet be steady and clear, though faint.

B. The Process of Judgment.

The analysis of the judgment consciousness is a matter of some difficulty. The reason is to be found in (1) its complexity, (2) its rapidity, and (3) in the close combination of the essential with the many unessential features of the process.

Observer M.

The following statements indicate the nature of *M*'s judgments.

1. Terms: The judgments may, for convenience sake, be grouped under a number of headings, although it is to be remembered that no hard and fast lines can be drawn and that exact rubrication is not always possible.

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[1] This is very commonly reported, *e. g.* "Pharyngeal contractions at each expiration seem to be the natural sort of innervation by which to attend to tones." Later, however, *Wh* says "it is perhaps partly accidental because, by taking thought I can make the intensity increase at each inspiration, and, furthermore, the image often fluctuates independently of breathing." *Cf.* the "innere Singen," mentioned by Stumpf, *op cit.*, I. 176-7.

(*a*). Exclusively tonal. This type is very rare, and found in '*equal*' judgments only.

(*b*). Auditory-visual, more frequent.

"V seemed to fill the place occupied by N and to be a repetition 'out loud' of my image." This type is closely allied to

(*c*). Auditory-visual-motor, in which the 'placing' is more emphatic.

"Image just appearing when V came and perfected it, for they 'melded'[1] perfectly." "Seems to be an auditory placing together of the tones as one would place two sticks side by side." "V higher in auditory scale; feeling of actually placing it there."

(*d*). Visual-motor, in which the auditory element is practically negligible. "I placed the notes visually in a ladder scale."[2]

"V fell in place visually just below N." "I could *see* the comparison. Judgment based on this visual feeling, coupled with strain in the forehead." "N was high up in my visual scale (ladder). V took its place below N at once. Judgment was visual and immediate. Later came the auditory verbal formulation, '*lower*.'"

(*e*). Purely visual, rare.

"N caused a peculiar feeling as if something dark were pressing on my eyes; at the sounding of V, it was lifted, and a slightly blue, bright gray appeared. Knew at once that it was '*plus*.'" "Very light blue color with N. Judgment made by comparing this color with what might be the color of V."

(*f*). Auditory-motor, rare.

"Judgment made by direct comparison of tones, aided by muscular strain in throat."

(*g*). Purely motor (strain sensations, usually of eye or scalp muscles).

"Although I saw nothing, I was comparing visually." "Eyes dropped on N, raised on V. Made an easy and certain judgment of '*plus*.'" "Immediate judgment, for at V there was a slight movement of the eyes as though placing one object below another."

(*h*). Affective (always with other elements).

"Feeling of 'melding' of tones. Pleasant feeling as though something were satisfied."

(2). Dependence of judgment upon the image.

a) The presence of a satisfactory image usually favors the decision, but (*b*) with the longer intervals, 'certain' judgments are made when no image is present, and, on the other hand, (*c*) the presence of a good image does not guarantee a satisfactory judgment.

Illustrations are: "Judgment not immediate, but almost so. Image entirely gone [60 secs.], yet V seemed certainly lower" (correct). "Best image I have had yet (20 secs. interval), but V weakened and destroyed it. Judgment immediate, but uncertain [and wrong]; reconsideration did not make it certain."

3. Speed of judgment.

(*a*). The majority of *M*'s judgments are immediate, *i. e.*, made with-

[1] A word coined by *M* to express the feeling of '*equal*' judgments. It is, she says, not exactly either 'welded' or 'melted,' but between the two.

[2] This is an early and a very prevalent type. It is found, excepting in a few cases, with judgments of '*higher*' or '*lower*' only.

out conscious comparison (decided always before V has ceased sounding, one second). The image may be present or not. The greater part or 73% of the immediate judgments are correct. This type prevails when D = o, 68% of the judgments then being immediate.[1]

(*b*). (1) Conscious comparison, *i. e.*, the voluntary relating of the image of N to the image of V after V ceases, is less frequent on the whole, but it is more frequent when $D = \pm 8$, 57% of these tests being judged by comparison. (2) Judgments involving comparison are oftener wrong than right. (3) Comparison is a clumsy device, used in cases of doubt.

"V different from N, but could n't tell the direction, so I finally decided by trying to recall both tones."

(*c*). Judgments in which the decision is reversed or debated are not uncommon. There is an immediate judgment, then indecision followed by laborious comparison, and usually by a change of judgment. It is especially interesting to note that in three-fourths of these cases the first 'immediate' reaction is correct.

4. Certainty of judgment.[2] In 269 cases *M* reports 195 'certain' judgments. Of these the majority (127) are correct. On the other hand, of the 74 'uncertain' judgments, the majority (46) are wrong. The certain judgments are distributed thus: when D = o, 72; when $D = +8$, 59; when $D = -8$, 64.

5. Judgments of difference without knowledge of the direction of the difference are quite common.[3] They are, for the most part, recorded only when V really differed from N. The judgment 'different' seems to be more easily and more quickly aroused than the judgment 'higher' or that of 'lower.'

"My judgment of difference was immediate, but that of the direction was later and quite slow."

Observer W.

1. Terms.

(*a*). Exclusively tonal. (1) Qualitative. This is the typical form of judgment for *W*. It is usually characterized by deliberate comparison of memory images of both tones.

"When V came I listened to it, then heard the first (N) again, and then judged the second lower by comparing the two images." "Seemed to identify V with N auditorily." "Judged in tones and then translated into words." This form occurs also when D differs from N, in contrast with the case of *M*. "V seemed to run in on image, and there was a change."

(2). Auditory judgments are occasionally based upon the intensity instead of the quality of V.

For example: at 60 seconds standard *e* was given both as N and V. *W*'s judgment was '*lower*.' "No image left, but when V came it

[1] These facts correlate well with the further fact that for *M* there are more right cases when D = o than when $D = \pm 8$.

[2] For further discussion see pp. 445-6.

[3] Reported also by Wolfe and by Angell and Harwood and by Preyer (Stumpf, *op. cit.*, I, 313).

just appeared to me that it was lower than the first by feeling more intense."[1]

(3). *W*'s unmusicalness is well exemplified by the fact that he is often unable to differentiate quality from timbre, and that, accordingly, large numbers of decisions are based upon what he terms a difference in timbre.

We have already mentioned that the reeds used were carefully selected to avoid any such differences, but convincing proof of the subjective nature of this alleged distinction is afforded by the fact that in the cases when D = 0, *W* frequently reports "2nd more reedy," and again in the repetition of the same standard and variable (*e. g.*, *a* and *a*—8), the report is once, "first clearer," and again, "first more reedy." It is likewise impossible to see any uniform connection between *W*'s estimate of the timbre and his decision. To be sure, he says once "2nd had that reedy quality more and, hence, is *lower*," but on the same day he makes several judgments of '*higher*' when the "second is more reedy."

(*b*). Auditory-visual, but (unlike *M*'s) with the visual features subordinate and inessential.

"Almost always (?) when I judge I visualize the tonometer and bellows." "Deliberately compared, and saw keys of a piano."

(*c*). *W* has no visual-motor or purely visual judgments.

(*d*). Auditory-motor, rare.

"I know how the sounds sound exactly (?), but just can't say whether it should be '*plus*' or '*minus*.' I tried to determine by articulating."

(*e*). Motor.

Both N and V often occasioned a "twitch in the ear." *W* thinks these sometimes influence his judgment; if the second twitch were stronger he would certainly say '*higher*.'

A sort of organic basis of judgment is once or twice found.

"At N felt a nervous feeling go through my whole body. When V came I said it did not feel at all like the first. I think I compared the feelings."

(*f*). Affective.

A single doubtful use of the affective reaction as a basis for judgment is this. "N caused a twitch in my ear. V sounded better and softer to the ear, so I at once judged 'lower.'" This instance may be, perhaps, reduced largely to intensity. Like *M*, *W* is most pleased by 'certain' judgments, but, since most of his certain judgments are based upon a process of comparison, he does not report that pleasure in quick, flash-like judgments which we have noted in the case of *M*.

2. Dependence of the judgment upon the image.

The doubtfulness of *W*'s estimate of his images makes this point difficult, but it is safe to say that (*a*) judgments may be formed after the image-less two second interval, though possibly the image does get formulated in the judgment, and that (*b*) judgments made by sudden impression, without the presence of any image, are quite rare.

We have already seen that the auditory excellence of the image

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[1] It is probable that this error of mistaking the intensity of V, as compared with the remembered intensity of N, as an index of '*lower*,' accounts for the peculiar prevalence of this judgment in the longer intervals, *e. g.*, 10 out of 15 cases at one sitting. Here again is evidence against Wolfe's appeal to the lessened intensity of the image as a source of the error = +. (Note our previous discussion, p. —.)

reported is probably questionable. The following is an instance: "Fell to noticing a twitch in my throat, and thus lost the image, and then the image got lost in a song, but at the judgment I had both tones (N and V) in my head to compare." (60 secs.)

3. Speed of judgment. It is difficult to classify *W*'s judgments on the basis of speed.

(*a*). When $D = \pm 8$, it is usual to have a quick judgment of difference, and a slow one of direction.

(*b*). Really immediate, flash-like judgments are very rare.

Even in his so-called 'quick' judgments *W* compares the two images. Thus *W* differs from *M* in every point under this rubric.

(*c*) Outside of the hesitancy in assigning the direction of a difference, just mentioned, the chief debated judgments waver between '*equal*' and '*lower*.'

An example of a less frequent class is the following: "I said quickly 'this is *plus* or *equal*,' and then reasoned that saying *equal* was only because they seemed almost *equal*, but that V was really a little *higher*. This all quick. Had images of both to compare."

4. Certainty of judgment. *W* has less 'assurance'[1] than *M*, yet the majority of his judgments are 'certain.' Contrary to *M*, his assurance is greater when $D = \pm 8$ than when $D = 0$. The majority (59%) of the certain judgments are correct; the majority (58%) of the uncertain are wrong. Uncertainty increased markedly after the 15 seconds interval.

5. Judgments of difference without knowledge of its direction are extremely common when D is 8, even with the short intervals.

Instances have already been noted. *W* suggests that this may be due in part to a confusion of the two images while they are being compared. "Compared the tones, knew they were different, but had trouble in deciding *which* was high and which low."

Observer S.

1. Terms.

(*a*). Tonal, very frequent, especially in long intervals, with all forms of D.

"Convinced myself of the '*plusness*' of V because it did not seem to harmonize with N." "Thought of scales as I had heard them sung, and this seemed like the interval c-b as one sings down the scale, and so I judged V *lower*" ($D = 0$). "*Equal* judgments usually seem to chord or harmonize tonally."

(*b*). Auditory-visual, infrequent.

(*c*). Visual, not common.

"N caused pale bluish-green, and V was the same. Recognized equality by color." "Heliotrope patches all through image and interval. These were reinforced by V, so said 'equal.'" By the addition of the place relations this type merges into (*d*).

(*d*). Visual-motor.

"N had a certain definite length, breadth and thickness, and V seemed to fit over it." "Image seemed like a horizontal line, and V

[1] Assurance is measured by the number of times 'certain' is recorded, without heed to the correctness of the decisions.

was placed in the same position. Made the judgment in these terms, though uncertain because the auditory relations did not seem to correspond with these." (Judgment correct.)

(*e*). Auditory-motor.

"V placed itself on N, and I made the judgment in these terms, though the auditory elements also entered in."

(*f*). Motor.

"I had a certain position for N, and I seemed to put it there, and felt it would stay there all through the interval. When V came it took a higher position without any effort on my part."

(*g*). Affective elements appear often in the judgment process, but they do not constitute an essential part. *S* has pleasure in 'certain' and generally in 'equal' judgments.

2. Dependence of judgment upon the image.

(*a*). The large majority of *S*'s judgments make use of the image either in its auditory form, or, less often, in its visual setting (place, lines, color, etc.). Conversely, the lack of the tonal image works the most damage.[1]

"Held spatial position of the image, but lost its auditory portion. When V came I could make no judgment because it was auditory, while my image was only spatial."

(*b*). Only a single instance of a sudden imageless judgment is reported, and that felt uncertain.

"Judgment an impression, not a decision." On the other hand,

(*c*). Occasionally a good image may be present without insuring a decision.

"Good attention, and good image, but I simply could not make up my mind between '*equal*' or '*different*.'"

3. Speed of judgment.

It is almost useless to speak here of the speed of *S*'s judgments, for unfortunately only 109 out of 270 tests contain the introspective indications required. Of those reported, however, it may be said that (*a*) slightly more judgments are compared than immediate, and (*b*) the majority of the immediate judgments are correct while the majority of the slower, compared, are incorrect. (*c*) A sort of comparison coupled with the method of exclusion is a curious feature of *S*'s judgments. With D = —8 it is so frequent as to be the rule rather than the exception. Almost always the result is correct.

"Compared the images several times. Decided they were not *equal*, and V was not *higher*, hence it must be *lower*." "Always have trouble with the '*minus*' judgments, and have to argue them out."

(*d*). Another very common and peculiar feature with *S* is the comparison of the feeling of the present relation of N and V with that of some just previous test or tests. This is a part of the many schemes (singing descending scale, visualizing piano keys and scale, etc.) used to keep the categories '*equal*,' '*higher*,' '*lower*' distinct, for owing to her unmusical nature *S* has apparently no deeply ingrained 'feel' for these relations.

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[1] *S*'s quantitative results, which are extremely poor, are to be laid to poor *sensible* discrimination rather than to a poor tonal memory. *Cf.* Stumpf, *op. cit.*, I, 289.

Examples are: "After recognizing a difference, I said '*minus*,' influenced by my two previous judgments of *minus*." "Judgment slow; thought first that the two were *equal*. Then thought of test 2 (third before this), and compared the two impressions (of 2 and 5). Then decided that V was *higher*." "This combination felt different from the preceding test ('*equal*'), and felt high rather than low, hence '*plus*'" (correct).

4. Certainty of judgment. (*a*) The amount of certainty was recorded in but 232 of the 270 tests. Slightly more than half (128) are 'certain.' The majority of these (76) are correct. The objective accuracy of the 'uncertain' judgments differs from the results of the other observers in that more, though but very slightly more, are correct than incorrect (53 correct out of 104 uncertain).

If we ask the reason for this, it is easily found in the method of making '*minus*' judgments just mentioned. The figures show that when D = —8, the majority of the 'certain' judgments are wrong, and the majority of the uncertain judgments are right. *S* makes many of her '*minus*' judgments by the method of argument and exclusion; they are troublesome, hence uncertain, but they are oftener right than wrong. Omitting these peculiarly constructed 'minus' decisions, the conclusions found for the other observers hold good for *S*.

(*b*) An interesting feature with this subject is the fact that writing down the judgment, or repeating the tonal interval several times, often brings on a feeling of certainty which was not present when the judgment was made.

"Thought this interval (tonal) did not seem exactly like the previous one (D = +8, judgment '*minus*'). Reflected that this might, however, be right, my previous judgment wrong, so gave the judgment '*minus*.' (D was 0.) After writing it down, I felt very positive that I was right."

5. As with the other observers, judgments of difference are more quickly and more easily made than judgments of higher or lower. This occurs only when D is really ± 8 vibs. With *S* it may even be said that judgments of higher or lower are, as a rule, made only after a preliminary assertion of difference.

6. An isolated instance which illustrates the automatic nature of the judgment consciousness as it is created by the conditions of experimentation is afforded by *S* who, while attending to the image during a long interval, mechanically passed a judgment of '*higher*' when a street car bell rang outside the building, very much to her surprise and amusement.

Observer F.

1. Terms. *F*'s judgments are of two types, an auditory and a motor, with or without an auditory fringe.

(*a*). Auditory. This type is always found with judgments of equality. V is felt to be simply a re-enforcement of the auditory image. Auditory-verbal phrases such as "That's higher" may be present in judgments of difference, but they are secondary.

(*b*). A single instance of a visual component in the judgment consciousness is the following:

"Saw image as a line in the space before me, and then V as another line shooting just below it whereupon the old one faded from view. At the same time a sense of relieved muscular strain was noted." We are inclined to class this under the motor type and consider the visual element as the result of some suggestion from the other subjects of visual proclivities.

(*c*). The auditory-motor or motor type is meant to embrace judgments which are characterized by pressure, strain, and organic sensations of any sort which combine to place the tones spatially in a vague manner. This type is always found with judgments of higher or lower.

Examples are: "Judgment conditioned by a loosening of the muscles (scalp?) on the left side of the head." "Based upon a further tightening of the muscles of the ear already 'set' for the pitch of N." "Recognition a moving of the head up and forward." "My 'set of the ear' means not only strain sensations, but also, apparently, an expectation of a certain sort of pressure. A low note gives a broad dull pressure, a high one a stronger pressure. In a '*plus*' judgment I feel this change." "Judgment accompanied by a pressure upward in the head."

2. Dependence of the judgment upon the image. *F* exhibits an irregularity difficult to explain, for

(*a*) many judgments are passed easily without the presence of an auditory image, but

(*b*) often the absence of an image precludes any attempt at a decision. It may be that in the latter case whatever serves to represent the image in (*a*) is also gone.

3. Speed of judgment.

(*a*). Of the cases reported the majority are immediate, *i. e.*, passed within one second and without comparison. There are 202 such instances and 164, 82%, are correct. This type is most common when D = + 8.

(*b*). Deliberative judgments are most frequent when D = 0. Only 23 out of 40, or 57%, are correct. *F* contributes one peculiar case of a very slow decision in which there were nevertheless, no image and no comparison.

(*c*). There is but one instance of a debated judgment.

"At first it seemed *equal*, and then suddenly recognized it as *lower*, and was certain."

4. Certainty of judgment. In 266 cases *F* reports 171 'certain.' Of these 145 were correct. 55 of the 95 uncertain cases were wrong. Certainty was greatest when D = + 8, least when D = — 8. Usually *F* had three or four uncertain tests in a group, perhaps indicative of a temporary lapse of attention or of a temporary loss of confidence.

In one test "V was higher, hence judgment instantaneous, but it was so much higher that I knew image must have flatted, so I was uncertain."

5. *F* never confuses the direction of a difference.

Observer L.

1. Terms. *L*'s judgments seem, perhaps as a consequence of his ex-

cellent images, to be substantially all of the auditory type. When other elements are present they are subsidiary.

(*a*). Auditory. These judgments may be quick, but they involve the presence of the image and a rapid observation of the relation of V to this image as tonal sensations. In the few cases reported in which the image was lacking just before V, *L* thinks that it must have "popped back" and thus entered the judgment process. Whether this is not the result of the logical bias in favor of comparison which we have already noted in *L* is very doubtful.

(*b*). Auditory-visual type, but once reported.

"Process of judgment involved a visualization of a piano keyboard. Tones were seen to be apart, V above N."

(*c*). Auditory-cutaneous (?). *L* often mentions that the sensation around the ears, which is external and quite pronounced, starts at N and gradually fades during the interval. If $V = N$, this sensation is picked up or re-enforced in a noticeable manner; if $V = N \pm 8$ vibs. this sensation is not intensified. At any rate it is a secondary phenomenon.

(*d*). Auditory-motor.

"There was a distinct representation of V being vertically above N." "Image localized just outside the ear. Thought, if V is the same, it must come right to the same locality, and it did."

(*e*). Affective elements appear only as a pleasantness at judgments of equality, especially if the tones were also low.

This pleasantness may account for the fact that *L* makes the error '*equal*' for '*plus*' 17 times as against the error '*minus*' for '*plus*' 4 times, and the error '*equal*' for '*minus*' 49 times as against the error '*plus*' for '*minus*' 10 times.

2. Dependence of the judgment upon the image. As already hinted, *L*'s judgments are unique in the constant use of the auditory image.

An interesting feature in this connection is afforded by his description of the relation of the judgment and the image in fairly long intervals. Following N the image of the clang itself ensues, first "wide" (strong), then "narrowing to a point." "When the point is almost reached I renew the image, so that it is wide again, by executing some imaginary humming for a brief time. If N comes when the image is 'wide,' judgment is easy, otherwise more difficult."[1]

3. Speed of judgment. Data sufficient for numerical results are lacking. At first *L* insisted upon deliberate comparison. Later he reported many rapid judgments, always auditory and with the presence of the image; the deliberative judgments[2] being exhibited only

[1] If we add to this description the further fact that such a process of renewal takes place according to *L* about three times in a 40 or 60 second interval, we have some facts not unlike Wolfe's phenomenon of periodicity. The likeness is enhanced by the fact that *L*'s curve for right cases shows peaks at 15 and, more noticeably, at 40 seconds. It seems plausible, then, that *L* represents a type of observer similar to those of Wolfe, using in the judgment an image which, either voluntarily or involuntarily, is renewed at intervals of time approximately constant for the same individual.

[2] The distinction is this: in the rapid judgment the image is present. As soon as V sounds it is known to be *equal*, *higher* or *lower* than the image. In the slow, deliberative judgments, exhibiting true comparison, no decision can be reached until, after V has ceased, the attention is turned alternately to the image of N and to the *image* of V. The first type is the more common with *L*, and, save when $D = -8$, the more accurate. It is never uncertain.

in difficult tests, whether because V and N seemed only very slightly different, or because some distraction had weakened the image.

(*b*). Debated judgments are not met with.

4. No quantitative statement of *L*'s certainty is possible owing to the lack of introspective evidence. One can merely say that his assurance was far greater than his correctness.

5. *L* never confused the direction of a difference.

Observer Wh.

1. Type of judgment. *Wh*'s judgments are nearly identical in type with those of *F*, being almost uniformly auditory, not in the sense that the variable tone is compared with the image of the standard, but in the sense that it is this *tone* V which is judged to be 'equal,' 'higher' or 'lower,' and not a color, or pressure or other sensation. But, it must be added that the position of V as an auditory sensation is for the most part determined by other than auditory elements, viz.: by those sensations which we have, for convenience sake, grouped under the term 'motor.'

(*a*). Purely auditory. Notably in cases of equality, V simply reinforces the auditory image. Rarely the auditory judgment is verbal.

"Judgment took one second, not to compare, only did n't feel sure till I had put the decision into words and said '*lower*.'"

(*b*). Auditory-motor. Judgments of either 'higher' or 'lower' almost invariably are based upon some more or less distinct spatial relation between the image and V, or upon an alteration of strain at V without any reference to either the pitch or 'place' of the image.

"'*Minus*' because of a distinct feeling of depression about my arms and chest." "Some sort of drop in my throat as well as a different external spacing for image and V. This spatial difference is certainly in consciousness before the fiat of judgment itself, whether it be its essential basis or not." "I hold the image steady at a certain point in my throat or externally, and in judgments of '*minus*' or '*plus*,' V comes in above or below this point." "V came into same space in my head, so judged '*equal*.' This is unusual; there is not apt to be any spatial reference in the equal cases." "V considerably separated from image, further from me and perhaps to the right; a sort of 'here versus there' feeling."

(*c*). Auditory-visual-motor. There are two rather hazy instances of visual components.

"V lower vertically, in a different place visually." "V farther to right, perhaps with a vague association of a piano keyboard."

(*d*). Unanalyzable. Certain judgments, especially at the end of long intervals are made, as *Wh* puts it, "by catching at straws;" such decisions are difficult of analysis.

"Judgment slow. Thought it was '*equal*,' but at the last moment I had an irresistible impulse to put down '*minus*,' though I don't see why this impulse came." (Correct judgment.) "The feel of familiarity which touches off the judgment of equality seems to resist further analysis."

2. Dependence upon the image. *Wh*'s introspection is uniform in

showing that keen attention to N is of importance to the decision, but that the condition of the image when V sounds is of secondary significance.

"Good image, but judgment took about 4 seconds, and was uncertain" (and wrong). "No image at all at end, but judgment very rapid and certain." "V was far below my image, yet I felt impelled to judge '*equal*' on account of some feeling of sameness not further analyzable." "Image split up into two, and I gave up trying to hold either one. V had feeling of *belowness*, no shadow of a comparison."

3. Speed of judgment. *Wh* found it very easy to subdivide the speed of judgment into several categories,—instantaneous, very quick, slow, deliberate comparison. The rate termed "slow" belongs in classification to the 'immediate' group, for it implies a time of about one second, and, what is of importance, does not imply any trace of comparison of images.

(*a*). Thus grouped, *Wh* has 220 immediate judgments, of which 194, 88%, are correct. Immediate decisions are slightly more common when $D = -8$.

(*b*). The 'compared' judgments number but 35, of which but 24, or 65%, are correct.[1]

(*c*). Judgments in which the decision is reversed or debated are occasionally found. These are almost always cases in which there is an instantaneous judgment for '*minus*' or '*plus*,' followed by a doubt and a fear that it might be '*equal*' because the difference is so small.[2]

4. Certainty of judgment. *Wh* had 200 certain, 70 uncertain judgments. The correlation of assurance and correctness is shown clearly, since 182 of the certain but only 45 of the uncertain cases are correct. There is greatest certainty when $D = +8$.

5. Judgments of difference without knowledge of its direction are infrequently reported, perhaps a half dozen in all.

In three of these cases the difference was finally judged correctly, *e.g.* "Knew difference at once, but had to compare tones to get its direction." "Judgment certain and quick, but it seems as if I noted the difference before its direction. Very vague spatial *belowness*."

C. Summary of the Introspection.

In the light of the fairly bewildering individual variations just recorded, one can but hesitate to generalize. The following statements are put forth, therefore, only tentatively, not even in the hope of covering all the main points of importance, but in the endeavor to present a sketchy outline of the course of the image and of the nature of the judgment process.

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[1] We should hardly expect *Wh* with his extensive practice to show a predominance of wrong cases with deliberated judgment as do some of the observers.

[2] This seems an exceedingly apt illustration of the use of the image in the judgment. The decision for '*minus*' or '*plus*' is based upon a 'feel,' a sudden relaxation of some muscles or a 'motor' spacing. There is in that moment no thought of the tonal relations of the variable to the standard pitch; only in the next pulse of consciousness does the auditory relation come into the focus of attention, if it comes at all, and only then does the doubt of the decision appear. The first decision is the one commonly recorded, and nine times in ten it is correct.

(1) The tonometer clang arouses a wide-spread reaction, adjustments of the organs of hearing, pleasantness or unpleasantness, visual, verbal and other associations, often of considerable vividness and detail, and organic 'sets' of various kinds. These supplementing processes help to give the auditory image an individuality; their nature, prevalence and distinctness depend upon the constitutional tendencies of the observer.

(2) Not until a noticeable interval after the stimulus does the auditory image appear. It then swells suddenly out into its maximal clearness and intensity, in the timbre of the stimulus, localized at the instrument, and usually devoid at first of all those adjuncts just mentioned.

(3) Left by itself it then decreases in intensity and clearness. To offset this, the observer has recourse to various memorial aids; he visualizes the instrument, contracts his throat with incipient humming (changing the timbre and localization of the image), and exhibits all those muscular phenomena which characterize active attention, with emphasis also upon certain similar phenomena (notably in connection with respiration) which are felt to be especially effective for attention to an auditory image. Despite these efforts, attention must wane, and with attention, the image. It suffers most noticeably in intensity, less in clearness, and least in quality (here by tending to flat or by getting mixed with other auditory images). Some observers exhibit a long inaccurate retention, others a shorter but more accurate retention.[1]

(4) As a rule the image, under the conditions of our tests, is of little avail for discrimination at the expiration of 30 seconds, while it is very often entirely gone at 60 seconds.[2] This decline and loss of the auditory image does not necessarily imply a corresponding decline and loss of the various supplementary features which played a part in the identification of N

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[1] C. Stumpf: *op. cit.*, I, 77.

[2] This is quite contrary to the conclusion of W. v. Tschisch, who says (*Dritter Intern. Cong. f. Psych.*, Munich, 1897, p. 108): "Ebenso ist es eine allgemein bekannte Thatsache, dass wir die Qualität von Gehörswahrnehmungen einige Minuten hindurch mit aller Schärfe behalten, während gute Musiker in dieser Beziehung über ein erstaunliches Gedächtniss verfügen." Stumpf's violin test (*op. cit.*, 230–1) is entirely off the point so far as it pretends to indicate the reliability of the tonal memory image. The tuning of a stringed instrument, according to our experience, may be effected with some accuracy, after any amount of elapsed time, by the aid of certain secondary criteria,—tension of the string, sympathetic resonance of the other strings, etc. Compare Bentley's results already cited, to the effect that brightness images could be recalled better at the end of five minutes than at the end of one minute.

and which may have persisted in the background, now to become themselves the objects of attention.

(5) When the comparison stimulus sounds, it is, under favorable conditions, immediately known to be 'equal,' 'high' or 'low;' this whether or not there is at the moment any trace of the auditory image in consciousness.

(6) If the image is present and V is identical, the experience appeals to the observer as distinctly auditory, V re-enforces, or flows into, the image; if the image is not present, the experience may still feel largely auditory; V is the same *tone*, a familiar *tone*.

(7) If V differs from N, the process is not, as a rule, felt to be so largely auditory; the attention is entirely taken by a complex 'something' which stands for 'high' or 'low.' (We use these terms advisedly in place of 'higher' or 'lower.') What the 'something' is, depends upon the individual; its core is usually a complex of strain sensations, its remoter elements visual or organic.

(8) Sometimes there is a feeling of difference not standing specifically for either 'up' or 'down.'

(9) If V fails to engender either the reaction of familiarity or of specific difference, the observer resorts to auditory comparison, *i. e.*, he hears the image of V alternate with the image of N. The resulting decision is usually uncertain and very apt to be incorrect.

(10) Pleasantness is the correlate of 'certain' judgments, not of any one of the categories 'equal,' 'higher' or 'lower.'

(11) The verbal formulation arises only after the decision has been made otherwise.

(12) The relation of speed of judgment to certainty of judgment is summarized conspicuously in Table III; that of certainty to correctness in Table IV; that of speed and immediacy to correctness in Table V.

TABLE III.

Correlation of Speed and Certainty.

	IMMEDIATE		COMPARED	
Observer	Certain	Uncertain	Certain	Uncertain
M	119	9	54	52
W	22	4	69	71
S	42	2	17	48
F	161	39	1	40
Wh	194	24	2	33
Total	538	78	143	244

It must be explained that in Table III the compared cases for *W* include the type which he characterizes as "quick comparison," and that the 17 cases for *S* include many instances in which the judgment is deliberated for the sake only of identifying its "feel" with that of some previous test, but without any comparison of images. *L*'s results are omitted because the data are insufficient. It should be further stated that in the case of *Wh*, the correlation is somewhat more detailed than the Table implies; thus, as a rule, instantaneous judgments are absolutely certain; quick are certain; slow, less certain; and deliberated uncertain. The 24 immediate but uncertain cases of *Wh* are nearly all from the longer intervals. There is an immediate judgment of '*plus*' or '*minus*,' but the difference is so very wide that there is uncertainty. So these few cases cannot be said to make against the generalization that immediate judgments are correct and certain.[1]

TABLE IV.

Correlation of Certainty and Correctness.

	D = 0		D = + 8		D = − 8		ALL D'S.	
	r	*w*	*r*	*w*	*r*	*w*	*r*	*w*
Certain	230	60	217	92	202	83	649	235
Uncertain	72	91	68	67	96	68	236	226

TABLE V.

Correlation of Immediacy and Correctness.

		D = 0		D = + 8		D = − 8		ALL D'S.	
	Observer*	*r*	*w*	*r*	*w*	*r*	*w*	*r*	*w*
[illegible]	*M*	38	8	26	7	15	14	79	29
	S	12	3	8	8	5	11	25	22
	F	44	19	67	7	53	12	164	38
	Wh	62	11	62	9	70	6	194	26
	[illegible]tal	156	41	163	31	143	43	462	115
[illegible]	[illegible]	11	15	12	24	27	17	50	56
	[illegible]	2	8	7	9	12	7	21	24
	[illegible]	8	10	4	2	11	5	23	17
	[illegible]	8	4	7	6	9	1	24	11
	[illegible]	29	37	30	41	59	30	118	108

* [illegible] and *L* omitted for want of accurate data.

[1] [illegible] of Martin and Müller, *op. cit.*, 197 ff.

PART II.

The experimental work comprised under Part II is subdivided into four more or less distinct series.

Series 1.

The first series embraces six groups of 36 tests each with introspection recorded after every four tests instead of after each test as before. The qualitative results gained by this arrangement are not detailed enough to warrant its recommendation throughout a whole investigation. They demand a more substantial backing, such as is afforded by the method of Part I, in which introspection is taken after each test. A single time-interval (10 seconds)[1] and a single D (8 vibrations) are employed throughout. The image is actively held. The tonometer is replaced by the Stern blown bottle apparatus.[2] There are used four standard tones, *a*, *b*, *c*, *d*, corresponding to the settings 2, 10, 18, and 26 of the recording device upon the instrument, and to the pitches 233.6, 256, 276.4 and 300.8 vibs. respectively, and also eight variable tones (*a*, *b*, *c*, *d*, $\pm$8 vibs.).

The objects of Series 1 are to get a fairly large number of tests with a single time-interval, to see whether long practice changes the method of judgment, to compare the results of blown bottle tones with tonometer clangs, and to prepare the observers for tests with the bottle tones by the method of continuous change.

The observers are *M*, *S*, *Wh*, *B* (Miss A. M. Baldwin), and *O* (Mr. R. Ogden).[3]

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[1] Ten seconds was chosen because it affords a suitable time in which to operate the apparatus carefully and noiselessly, and because it is a favorable period for introspection.

[2] For a general description, see *Zeits. f. Psych. u. Physiol.*, XI, 1896, 4–12 and XXI, 1899, 361–4. In all the experiments of Part II the bottle is blown by compressed air from a tank in which the pressure is between 1 and 2 kg. per sq. cm., the pressure at the stop-cock being regulated, by manometer guages and a patent valve, at slightly less than ½ kg. per sq. cm. The slight hissing sound of the current of air may be lessened by a 'reducer,' a glass tube of small bore introduced within the large rubber feed tube where the latter attaches to the projecting glass tube of the bottle. Thanks to this device, the hiss was inaudible at the distance of the subjects. It is essential that the cog-wheels be heavily smeared with graphite to stop the rattle of the gearing, which otherwise not only distracts the attention, but, owing to the difference in the sound between going up and going down, indicates the direction of the coming V. As it was, we found it advisable to 'blind' the observers by simulating movements in both directions whether the actual V was to be 'same,' 'higher' or 'lower.'

[3] The quantitative results obtained from *O* are omitted from the Tables because illness prevented his participation in the work beyond this series, but full advantage has been taken of his introspective reports.

feelings," *e.g.*, "Felt image in mouth." "Unconsciously represented the feeling of N by moving my pencil-point the way it felt." In his judgments of 'higher' and 'lower,' *O* develops a new type, as they are based upon rather widespread strain and organic sensations. "If V differs from N, it affects my body differently. I have a rising feeling for higher tones, a lowering feeling for lower." There is one good illustration of the effect of fatigue upon the judgment process. "Got inattentive. Had to repeat the images of N and V alternately two or three times, yet I had good images and the difference was marked and certain, once I had rendered the decision."

Observer B.

During the second day's experimentation *B* reports that often N, less often V, rises in pitch just as the air is shut off.[1] This rise often causes the image to be obscure,—"Didn't know which part of the tone to remember,"—and, it is asserted, is the main cause of whatever hesitancy the judgments exhibit. The image appears after an imageless gap, is in the bottle timbre, located doubtfully in the head, with the usual fluctuations in intensity. *B* thinks that there may be a slight tendency for the higher images to flat, and a slight effort, chiefly facial, to keep them up. *B* has few slow decisions, even from the outset. Unfortunately she is unable to analyze the rapid-certain type, so that the introspective account of her judgments must be confined to a record of their certainty, speed and dependence upon the image. There is little light on the last point. The certain, immediate judgments are made with good, bad and

[1] This phenomenon is also reported a very few times by *O*, and *Wh*, while *M* and *S* merely say that at times the notes seem like a curved line, swelling in the middle, *S* adding that it is a change of intensity. The explanation of this seeming rise is difficult. Very careful trials show that at a certain position of the air-cock, when the air is nearly shut off, the second partial of the bottle tone can be heard with some distinctness. Now since the movement of turning the valve through a quarter-turn occupies but a brief fraction of a second, and since this partial appears only when the valve is passing through a single very limited position in the arc, it is clear that there can be only an extremely brief variation in the color of the tone as it is shut off. This variation may be perceived, subjectively exaggerated in duration, and misinterpreted as a qualitative change. Besides this, there is the possibility that the simple fall in the intensity of the tone, occupying, say, $\frac{1}{10}$ second, is in itself sufficient to engender the illusion. (Compare the subjective rise in a dying tuning fork tone. Stumpf, *Tonpsychologie*, I, 242 f., 254 ff., II, 237; also incidental reference to rise in tonometer clang, p. 432). If there is any purely qualitative objective error in the blown bottle, it must be a tendency to flat, for if the mercury be replaced by water, or even glycerine, one finds that the thrusts of the air-blast force the liquid, after the first moment of inertia, down the bottle and up into the variator, thus flatting the pitch. We never, however, observed any movement of this sort with mercury, nor was there any observable lowering of pitch. It seems, then, impossible to say whether the rise effect is entirely subjective or an illusion based upon a brief shift in the intensity or color at the end of the tone.

indifferent images; while, on the other hand, poor images sometimes entail uncertain judgments. The solution of this incongruity appears in the fact that the latter condition holds true only when there is general weariness of body, and hence less strenuous attention to N. If this be granted, it confirms the principle previously set forth, viz.: that good attention to N, not a good image, is the prerequisite of a good judgment. With *B*, the doubtful or hesitating judgments are most frequent when $D=0$, almost nil, 2 out of 60, when $D=+8$, and quite frequent when $D=-8$. It is an obvious corollary that judgments of '*plus*' are very certain, rapid and accurate (only one error in 60 tests); and, what is more, the difference is then much exaggerated, *e. g.*, V is judged to be a third, a fifth, or even an octave higher than N.[1] The introspection does not explain this excellence in '*plus*' judgments. We may assume that it is due to some tendency, not further explicable, to pass this decision. 'Equal' was actually pronounced 47 times, '*plus*' 72 times, '*minus*' 61 times. All certain judgments are made "as soon as V begins to sound." A wait of even two seconds would mean a doubtful decision. Fatigue may bring it about that both sorts of judgment take place; there is an instantaneous decision, "founded on impulse," followed by a comparison of the two images. It appears that not only tonal intervals, but also time-intervals are subject to overestimation, for some of *B*'s deliberated judgments are registered as occupying the preposterous time of 10, 20 and even 30 seconds.

Turning to those observers who participated in Part I, we have to inquire what new introspection is afforded by the conditions of the present series.

Observer M.

N causes visualizations less often, blue being especially predominant. Associations are quite frequent, as before: *e. g.*, "Like a cork bursting from a bottle of fermenting cider." "Like cobwebs and dust." "Buzzed in my head like a bee in a paper bag." The judgments are at first varied in nature, but, as practice with the bottle tones proceeds, they settle down into practically two types, the purely auditory for cases of equality and the auditory-visual-motor type for cases of difference. There seems to be much less visual aid than in the tonometer series, and much more muscular aid.

[1] Tonal intervals on the blown bottle are overestimated by all the observers. This fact is, perhaps, foreshadowed in the 'rise' phenomenon just discussed; it is further brought out by the distinctions made by the observers between the "high" "middle" and "low" standards used, although the interval from *a* to *d* is but 66.2 vibs., equivalent in this region to about a major third.

Illustrations are: "With equal tones, judgment does not seem to be spatial, but seems to be a flowing together, like a mixture of two glasses of water. It is thoroughly auditory and not at all visual." "Before V sounds, my eyes, which are shut, are fixed on a level; at V they move, or tend to move, up or down, as V dictates, thus denoting higher or lower." "I can say positively that it is not the image, but the first position taken by V that determines the relation of the two." "I feel or see a raising or lowering when V is higher or lower." There is one curious case of disparity between the 'expressed' and the 'felt' judgment, "Verbal judgment was 'equal,' but mental judgment was '*minus*.'" With the bottle, difference and direction are both cognized at once, with the exception of one instance. Quantitatively the peculiarity of *M*'s results in this series is the frequency of the error =—which occurs 15 times in 60 tests. It seems impossible to explain this frequency whether by appeal to the introspection or to the distribution of the errors when D is ± 8.

Observer S.

The introspection is very similar to that of Part I. The tones arouse fewer colors than the reed clangs, but perhaps more general associations of objects, most frequent being steamboats and trains, from the whistle-like sound of the bottle. "Had a vivid picture of something moving very swiftly, like a train. Saw it begin and stop. This recurred through the interval and V was like it." The apparatus is often strongly visualized to hold the image.[1] In the judgments the qualitative change is several times misinterpreted as an intensive difference only. There are a very large number of doubtful cases,—cases in which, had the impulse toward a decision been followed, the majority would have been correct. *S* is able now to distinguish three speeds of judgment; a very quick, completed before V is half over; a quick, made directly after V ceases; a slow, necessitating two or three comparisons of images. Direction is still cognized after, and less easily than, difference, and in one case light is thrown upon the mechanism of judgment as it is conditioned by what might be called ease of reproduction. "I knew the difference easily, but not the direction. Said 'lower' because it is easier to say."

Observer Wh.

In general, *Wh* has similar reports to those of Part I. Like *M* and *S* he has more associations with the bottle tones, *e. g.*, "N tight and strained, like a quarrel or some distressing situa-

[1] *Cf. Wh* in Part I.

tion." "The 'choppy' start of the tones is pleasant, like the plunge into water in diving." "Verbal association—'clownish,' a laughable tone as if it tried to be mock-serious, or to be somebody big in vain." The image is in the bottle timbre, localized at the instrument, and held strongly by visualization of the machine. Toward the end of the series the incipient singing mentioned in Part I becomes less prominent. "No tendency to sing or contract the throat now. The idea occurred to me during one interval, but seemed odd and foreign to my present method, though these tones are within the region of my voice." There is none of the double image effect so frequent before, but instead such effects as these,—"Had an idea that there are really two sorts of images, of the same pitch however. One I try to hold; it is weak and bothers me; the other, clear and intense, asserts itself like an after-image, without volition." In the first few days also there is "an alternation between the bottle image and another one in my own voice." On the first trial of the bottle *Wh* has very poor judgments indeed, but it is imposible to say whether because of the newness of the tones or because of the loss of practice during the summer vacation. The judgments take place much as in Part I. The following introspections are inserted, as they make the nature of the process somewhat clearer than before. "Some 'equal' judgments have nothing about them but simple familiarity; there is no tonal reference at all." "In this 'equal' judgment, I had an effect of repetition and coincidence, and an association of touching a place on the skin twice, as in experiments on cutaneous localization, in which, if you happen to hit the point stimulated, you know it because it is more sensitive. Just so my auditory apparatus seems more sensitive to a repeated tone." "The muscular strains which give a spatial setting to judgments of difference are certain enough, but very difficult to analyze farther; they seem simply to stand as symbols of auditory rise or fall and are hence very elusive when attended to for their own sake." "When the D is subjectively very wide, the judgment consciousness is apt to be very spatial. The image is (almost) visualized as a thing here, and V as a thing there, about five inches away, to the right and higher, or to the left and lower." "The verbal contents of the judgment, *e. g.*, [illegible] are not as usual present until some [illegible]ion is made." "Fatigue interferes [illegible] with the judgment." "If the [illegible], it is a part of the judgment con[illegible]dard of comparison, for it is to V only [illegible], often the images are poor or lacking, [illegible]on just the same."

Series 2.

This section includes two groups of 36 tests with each subject, 10 seconds interval, but made with the tonometer. For the sake of distribution of practice they are interpolated in Series 1, but may be conveniently regarded as a distinct series. The object is to gain additional data for the comparison of the tonometer and the bottle as sources of sound. The image is, as before, actively held; the observers are those of Series 1, with the exception of *O*.

The most obvious quantitative result is that the shift of instrument diminished the number of right cases in the first trial. In the second, every observer improves; the total number of right cases increases 15%. This increase is most striking for *B*, who had never heard the tonometer before. Her introspection shows that the, to her unusual, 'reedy' color of the instrument obscured[1] at first the purely qualitative variations given; quantitatively this influence shows in the fact that in the 24 tests in which V differs from N, there are nine errors caused by judging 'equal' instead of 'higher' or 'lower.' But these effects are not limited to *B*; even observers *M*, *S* and *Wh*, who have had one year's practice upon the tonometer, find it very difficult to adjust themselves at once to the change in the stimuli; images are at first poor and uncertain,[2] while the judgments are slowly made, with little assurance or accuracy. As in Part I, the clangs arouse brilliant photisms in the case of *M*, while *Wh* falls back into the habit of contracting the pharynx to hold the image, a tendency which is strong in Part I, but gradually lost in Series 1 of Part II. This tendency seems engendered by the higher pitch, not by the altered color of the clangs. There is also an indication of a shift in the subjective standard of excellence for *Wh*. "I think that what I am calling a good image now is not as a rule up to those termed 'good' last year; perhaps because I don't need the images so much now."

Series 3.

This series comprises two groups of 12 tests with each subject, bottle tones, with 40 seconds interval. The object is to get introspections and data for bottle tones for a longer interval than 10 seconds. The observers are those of Series 2; the image is actively held; introspection is written at the end of each test. A ready signal is given just before V. The most

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[1] Stumpf, *op. cit.*, I, 235. "Aber selbst die Frage, welcher Ton höher, wird bei ungewohnter Klangfarbe schwieriger."

[2] Apparently indicative of a loss of practice in ideating a specific sort of image, rather than a loss of practice in attention. *Cf.* Stumpf, *op. cit.*, I, 75 ff.

that while I make very rapid judgments (usually correct also), I don't like to put down 'certain' till perhaps one second after the first impulse comes" (*Wh*).

Series 4.

The four observers of Series 2 and 3 are given 36 tests each, bottle tones, 10 seconds interval, but now, for the first time, with instructions to forget N as soon as possible after it is given. To aid in this attempt, smells are employed as distractors. Some 30 odors,[1] both pleasant and unpleasant, consisting of essential oils, perfumes and powders, are enclosed in similar vials with the names concealed. The observers pick up a vial at random (avoiding repetition) and attend vigorously to the odor at the cessation of N. Distraction is maintained, if possible, until V sounds.

We were led to employ odors as distractors, first, by the successful results obtained from them in this laboratory by a previous investigator,[2] and secondly, because our preliminary tests had showed the futility for this purpose of such processes as adding and reading. We hardly expected to attain complete distraction for so long a time as 10 seconds, since the earlier experiments had merely indicated a possibility of distraction for five seconds, but, as Table VI shows, we were happily disappointed. When supplemented by the introspection, this Table gives a comprehensive idea of the effect of distraction. From both sources, the following conclusions may be drawn:

(1) *Distraction slightly lessens the total number of right cases for all observers*, though, it may be added, this effect is not due so much to the loss or impairment of the image as to the time consumed by the shift of 'venue' at the moment V sounds; V fails to 'sink in' at first if the distraction be complete.

(2) *We must distinguish four different degrees of distraction*: (*a*) no auditory image throughout the interval or in the judgment, (*b*) a momentary, very faint reappearance of the image once, twice (or very rarely three times) during the interval, but entire absence of it thereafter, (*c*) an appearance of the image near the end of the interval, persisting into the judgment consciousness, (*d*) no appearance of the image until V sounds, usually not until V has ceased. The Table shows 84 instances of (*a*), 33 of (*b*), 13 of (*c*), 14 of (*d*), while the sum of (*a*) and (*b*) gives 117 out of 144 cases in which the image is effectually eliminated from consciousness during the period of the decision.

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[1] A set prepared by Fritzsche Bros., New York. For the qualities included, see E. B. Titchener, *Experimental Psychology*, New York, 1901, Part II, 125 f.

[2] L. G. Burch, this *Journal*, IX, Oct., 1897, 45.

ing the intensity of the odor with each nostril" (*Wh*). The remaining introspections concerning the judgment are all from *Wh*. "The 'wave back' of the auditory image seems to come when my first wave of attention to the odor dies low. It is not hard to reinstate the smell consciousness. I have a hazy feeling that this recurrence, brief and vague as it is, may somehow make the judgment easier; that it leaves some effect which would not otherwise be there." "At about the 6th second the image was back for a moment. I thought, 'that 's not it.' Judgment was made without image, a wide D, spatial-motor setting, and at once came the thought 'that image *was* all right,' *i. e.*, instead of the comparison process, I really checked the image by the imageless judgment." "Good distraction. Judgment immediate, but not quite so fast as in experiments without distraction. There is no hesitation or comparison, but the feeling does not 'flash out' as it does sometimes. Moreover, after many of the quick judgments I have doubts. Often I almost forget what to write; the judgment consciousness is more fleeting. In the previous test the judgment was certain when made, but uncertain at the time I wrote it." "Judgment just a quick impulse to '*plus*.' As I wrote it down a sudden uncertainty arose. This uncertainty was clearly due to the presence in the fringe of consciousness of some other judgment. If but one judgment arises I am very certain; if two arise with one distinctly predominant, I am fairly certain; if balanced in strength, I am in a state of doubt and considerable unpleasantness."

This concludes our attempt at the qualitative analysis of tonal memory as it is investigated with the use of discrete stimuli and the modified method of right and wrong cases. In a subsequent article we propose still further to examine the judgment-consciousness by the aid of the continuous change method, and to give a general résumé of the results of both methods.

INFLUENCE OF THE IDEA OF ÆSTHETIC PROPORTION ON THE ETHICS OF SHAFTESBURY.

(Inscribed to Professor Max Dessoir.)

By M. F. Libby.

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Note.—In the British Museum I found a very full bibliography under Cooper, "3rd Earl."

Introduction.

The following is an essay toward estimating the influence which certain æsthetic notions, and especially those of proportion and symmetry, more or less directly, but often unconsciously, may exert upon ethical theory, and through that, upon conduct.

It is certain that a simple preference for symmetrical arrangement has influenced the political history of countries by affecting the circumstances of debate and the division into parties; and that matters so vital as the size of a family have been by a taste for even numbers, or a desire for equality of the score of sex. In the section on *Proportion and* will be shown how profoundly such preconceptions ce a complete *Weltanschauung;* and the ethical im- good or evil of a sensitive appreciation of artistic suggested. It has long been known that Shaftes- s are those of an æsthetic mind strongly interested d religious questions, but the extent to which those moulded by two or three closely allied notions, pro- mmetry, harmony, has never been brought to evi- it is hoped that the effort to do so will both demon- ermanent worth and rich content of his works, and

at the same time bring into clearer light his relations to later philosophers, such as Schelling and Herbart, whose main thoughts he foreshadowed.

An attempt has been made for the first time to show that the lack of moral seriousness charged against Shaftesbury's Ethics (Butler and many others, and Wundt, s. 327) results not from any inherent defect in æsthetic ethics in general, but only from Shaftesbury's seeming lack of feeling for what I have ventured to call transitional or provisional forms. (See page 491 of this essay.) And this criticism goes so far as to raise the question whether the beautiful in conduct is not rather honor than goodness, and with that whether the good in conduct is not rather pathetic, tragic and sublime than beautiful in the strict sense. This essay was finished just before Dr. Rand's book appeared; that work fully confirms the estimate taken of Shaftesbury's austerity.

A study of Shaftesbury suggests the unexplored wealth of ideas lying hidden in æsthetics and in literature, which call upon modern ethics and psychology for investigation and classification.

§ I. Proportion as Understood by Shaftesbury.

The word proportion plays a considerable *rôle* in various branches of science, such as mathematics, chemistry, music, and æsthetics. Rhetoric has its "law of due proportion," which declares that a thought shall receive prominence according to its importance in the whole piece. In ethics the idea of proportion was clearly grasped already by Aristotle. In æsthetics great stress was laid upon it by the Greeks, but Plotinus discarded the ideas of proportion and symmetry as unessential; and the Greek views of æsthetics had no real vitality from the time of Plotinus to that of the renascence. From the earliest times books have been written on the proportions of the human body. These culminate in Zeising's work in which he argues at great length that *beautiful* proportion can be formulated in the law of *the Golden Section*:—a: b :: b: a + b, when a is the smaller and b the larger of two parts into which an object is divided. Fechner,[1] Theodor Vischer,[2] and others raised objections to this theory, chiefly on the grounds, (a) that Zeising[3] chose this point of section quite arbitrarily (*e. g.*, in the human body, though the navel, a section supporting the law in a remarkable manner), and, (b) that where an object is divided horizontally the most generally pleasing section is a bisection.

[1] Vorschule der Æsth.

[2] Das Schöne u. die Kunst. Pub. by R. Vischer, '98.

[3] Proportionen des Menschl. Körpers, Æsth. Forschungen.

But both authors were impressed by Zeising's experiments, and found much to confirm the opinion that his theory contains an important truth. Zeising's book contains a history of the idea of proportion. He made extended applications of his principles to moral and religious questions.

In the mathematical usage the word proportion is clear and unequivocal. In every measurable object each part bears a quantitative relation to the whole, but this ratio is not, as such, a relation of proportion. The essence of the idea consists in the equality of two ratios, $a : b :: b : b^2/a$. Aristotle understood proportion clearly in this denotation, and declared that it was an idea not confined to numbers as such, but *applicable to all to which numbers can be applied.*

It is sometimes said that the word *proportions* is used where *portions* would be more exact, but this criticism itself is perhaps founded on a misapprehension. It is true that a case of proportion absolutely requires a relation of four terms. If one now should say that a certain mixture requires a certain proportion of a certain ingredient, one might at first suppose that *amount* would be the more exact term. But *it often happens that in a case of proportion the second ratio is understood.* Indeed a judgment of proportion may be reduced in expression to a single term. To use a homely illustration, "That's too much sugar," may mean, the amount of sugar does not bear the relation to the amount of tea in the given case, that the amount of sugar bears to the amount of tea in the most agreeable case. Proportion may be predicated of any measurable objects whose parts can be compared with corresponding parts of standard objects, whether the ground of selection of the standard be beauty, agreeableness, utility, mere fact (standard of height in men, *e. g.*), or any other.

The peculiar quality of *æsthetic* proportion is that the ground of comparison of ratios is *beauty, or some other modification of the æsthetic judgment,*[1] such as humor, sublimity, the typical.

Symmetry is a case of proportion, but involves another idea in addition, namely, that of mirror-like reflection about an axis. In the history of the evolution of the art-consciousness there is observable a mysterious change and advance in the notion of symmetry which may be summarized thus: (1) a love of simple lateral symmetry, as in vases and Greek temples—a kind of symmetry often occurring in nature; (2) the growth of a symmetry of *interest, e. g.*, in a picture, a temple balanced not by another temple, but by some equally interesting object, such as a grove with human figures; (3) a tendency of sym-

[1] See Groos's Einleitung in die Æsthetik, S. 205, for difference between *beautiful* and *æsthetic.*

metry in the old sense to disappear altogether in a mysterious harmony of the perceiver and the object perceived (mirror-like symmetry of natural object (non-ego) and object in the æsthetic "Schein"), so that pictures, and especially landscapes, of a high degree of spiritual interest, often *neglect altogether the symmetry of composition*. This last way of regarding objects tends to make the selection of the standpoint ("station-point") for sketching less important, and *treats all nature as equally* "*beseelt*."

But the difficulty about proportion begins when the notion is applied not to simple objects of sense, such as flower-arrangements, cells of bees, shapes and orbits of planets, composition of pictures, structure of temples, etc., but to objects of thought, such as a "beautiful geometrical proof," or of moral ideas, such as benevolence and self-seeking, or of human passions, such as jealousy, ambition, love of honor, etc. The question raised by a study of Shaftesbury is, above all others, this: do terms such as proportion and symmetry (which apply in the strictest mathematical sense to statues and pictures), apply properly (or only figuratively) to the subject-matter of ethical theory? Has the conception of *giving harmonious form to the moral world* any definite meaning? Shaftesbury holds that ethics is a branch of æsthetics, and that the notion of quantity is strictly and most practically applicable to character and to moral or social relations. His view is directly opposed to that of those who teach that "das Schöne ist sinnenfällig," "die Poesie ist sinnlich;" the maxim, "Es muss absolut etwas da sein für unser Auge oder Ohr," before the æsthetic judgment is called into play, does not appeal to his conception of beauty; but when one reads the dictum of Volkelt[1] "ich werde das Menschlich-Bedeutungsvoll als den alleinigen Gegenstand der Kunst hinstellen," or Herbart's bold assertion that moral ideas are legitimate art-material, then one feels that Shaftesbury would have agreed heartily, and that these two principles are fundamental assumptions of his system. The question here is as to what the so-called "concrete medium"[2] of artistic expression really comprises.

The word *concrete*[3] which occurs in so many definitions of art-forms is generally taken to be a perfectly clear and definite term, but it is in reality both obscure and vague. The word may or may not denote an object of sensation, and such words as *act*, *extent*, *grateful*, *reverent*, are quite as concrete as *brick* or *paint*. No one reading the literature of æsthetics can fail to observe that words like *sensuous* and *sinnenfällig* are regarded

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[1] Æsthetische Zeitfragen.
[2] Encyc. Brit. Art. *Poetry*.
[3] Jevon's Lessons in Logic, p. 20.

as synonyms for *concrete*. The most general meaning, in fact, is "physically existing." At first glance, too, this seems satisfactory, but we shall see the results. Marble, bronze, stone, brick, wood, iron, paint, violin-strings in vibration, are the "concrete media" of music, painting, architecture, sculpture; they all have physical existence and offer something to eye or ear. Then, too, take poetry and the drama which Kant and Hegel writing in the age of German poetic genius rank among the arts: poetry has for its medium *language*, which reaches us through the ear, and is also "concrete" or "physically existing." That this view is wide-spread needs no proof, for it is well known that many definitions of poetry declare that words are to the poet what paint is to the painter, etc. But this may have another meaning which we shall discuss presently. Is language, then, in this sense a concrete medium for the sensuous imagination? Does it bear the relation to that which the poet would convey to his reader which marble bears to that which the sculptor would convey to the student of statues? The organs of speech are as real as violin-strings, and the sounds as real as musical sounds; but even if we assume that spoken language is essential to poetry can it be argued that spoken language as such, *as sound*, is an imitation of what is in the artist's imagination in the same sense as a statue, a sonata, or a picture is? It is notorious that when we say a word or phrase *sounds* badly we are hardly ever thinking of its *sound* as such, and that if such expressions were in a tongue utterly unknown their "sound" would not offend.

Language, even as communicated from the printed or written word to the eye, must certainly be said to have physical existence, but every medium of communication of ideas whatever, every such medium conceivable, must have physical existence, hence to pick upon *physical existence* as the defining mark of artistic expression, as distinguished from philosophical or scientific expression, is a mark of confused thinking. Words as sounds are not only not (except in rare instances) known as *imitative symbols* of what they communicate, but they are widely different in different lands, which sharply distinguishes them from such media as painting and sculpture employ, and which are intelligible to all mankind.

The other meaning of "concrete," as applied to poetical language is,—suggestive of a concrete image. The physical existence of the words as objects of sight and hearing certainly does not make poetry art, urge the holders of this view, but the physical existence, or *the imaginary physical existence of the images roused* by the words is essential to poetry. Abstract poetry is no poetry, they argue, and by abstract poetry we mean that verse whose words do not arouse images of physically

existing objects. This position is not easily refuted, is indeed largely true, and requires careful consideration inasmuch as it seems opposed to the idea that moral ideas are legitimate art-material, and to the idea that art may deal with *all that is of human interest*. There is a third class of critics, chiefly close students of painting, and sculpture, and architecture,[1] who boldly deny that poetry is an art in any but a figurative sense; and this opinion is encouraged by the fact that "art" in the universities is apparently confined to the three arts above mentioned.

If we regard poetry historically we do not find that poets avoid moral ideas, or ideas which do not take the form of sensuous images in the mind. It is true that sensuous imagery is abundant in great poetry, but the greatest poets, such as Homer, Dante, and Goethe, have taken the deepest interest in moral ideas, and the English poets have been pre-eminent for their serious consideration of moral and ethical relations and ideas as the names of Chaucer, Spencer,[2] Shakespeare, Milton, Dryden, Pope, Gray, Cowper, Burns, Wordsworth, Shelley, Byron, Browning and Tennyson, may serve to suggest. In many of the finest modern poems, by Arnold, Whittier, Bryant, Lowell and others, the treatment of the moral interest is the chief means of pleasing; they are certainly not primarily didactic, but they please *in* teaching. Are we to say that these are not poetry, and that their authors are not artists, or are we to define poetry inductively and assume an evolution of the art-consciousness? Is it necessary for one to reject the work of all the great poets in order to cling to the maxim of art for art's sake, or may one here, as elsewhere, allow the conception of growth and development to rectify the definition based upon a mere "*apriori*" or ideal conception of art? If one take a broad view of the term *moral* one may argue that no art product whatever has succeeded in rejecting all moral assumptions, or more or less clearly conceived ethical principles. If we enquire how it stands with the "real arts" in this respect, *do we find that the dream-object is confined to the sensuously interesting?* The facts are precisely the opposite. Indeed it is difficult to think of an old master, from Giotto to Rembrandt, who has not frequently allowed the didactic or the allegorical tendency to carry him too far to be quite pleasing. But within the list of works that are prized as pure art how little the evidence goes to show that the dream-object is not at all concerned with moral ideas. Take the etchings of Rem-

[1] Many admirers of the pessimists consider Music, "die künstlerischste Kunst," as Prof. Dessoir calls it.

[2] *Cf.* the remarkable Introduction to the *Faery Queen*, a work of the richest sensuousness.

brandt, take the *Hundred Guilder Print*, the *Return of the Prodigal*, and many more. In statuary take the Greek mythological forms, how overflowing they are with the purest moral significance. Music often has similar influence.

It is true on the other hand that there are poems by Keats and Blake (only a few, however), and paintings by Corot and Whistler, and a good deal of music, which have very little concern for those ideas of man's relation to life and nature which we call moral. These are not the chords, but the overtones of the social harmony, they are the art not of man as he is, a striving and developing being, but of what he aims at being in some ideal republic,—a pure and spiritual *play-art*.[1]

From the historical argument it follows that moral ideas are elements of the dream-object. But now it may be objected that while moral ideas enter into works of art they are not artistic elements of those works. In the *Hundred Guilder Print* the lights and shadows are dreamy and charming, the composition is mysterious and suggestive, we easily meet the picture halfway, flow into it, and appropriate it, and delight in it with tender spiritual sympathy. It is true that the picture represents Christ healing the sick, and that his attitude, and expression, and the strange atmospheric effects that surround him, suggest the most moving historical, moral, and religious, and even philosophical ideas, but these, according to the view under discussion, are not artistic elements of the picture as a picture.[2] Surely this view is untenable. *In any work of art the highest criterion is the harmony and unity of the total impression*. All that is not a help is a hindrance. It may take years of study before a spectator realizes the unity of a picture, but if study only tends to rip it apart how can it be said to be a harmonious whole?[3] Now the more one dwells on the meaning of this picture the more its lights and shadows gain in spiritual power, the more beautiful become the delicate drawing and the magical shading, and, therefore, it appears that *the moral ideas are harmonized in the total effect*, and that they are elements and important elements in the art-effect. Only when the moral ideas in a picture are so obtrusive as to rob one of freedom to enjoy it as a disinterested bystander,[4] not committed, as a bystander, to any set of opinions, do they cease to be elements of its art. But what follows from this? One result is that the only consideration for the artist is, not to exclude moral or even religious ideas from his dream object, but

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[1] Compare Ariel's songs in *The Tempest*.

[2] *Cf.* Stern's "Einfühlung und Association."

[3] One cannot err in studying art if one strives for the *artist's* attitude.

[4] The will and attention must be left free.

to keep them under control and to handle them with a free humor, however earnestly. A fair-minded Buddhist could enjoy the *Hundred Guilder Print* because its moral content does not clash with broad ethical truth; but it is a profound error to deny that it contains moral truth because it offends no one.[1]

If now it be admitted that moral ideas may be treated as material for art, provided they be kept in pleasing proportions, it becomes necessary to enquire what proportion means in this connection. Here again it may be said, and has, in fact, been said repeatedly, that proportion is a term applicable to objects having physical existence (or so conceived), but meaningless when applied to mere ideas. The arm of a statue may be too large, but how can benevolence be measured? Now it may be made clear at once that objects of thought which have no physical existence may yet be measured mathematically with the utmost exactness. Take for example the idea of *time*. The assertion that a second bears the relation to a minute that a minute bears to an hour is a perfect example (in the sense intended by Aristotle) of proportion, for time is something to which number can be applied, yet time is less tangible than those passions and affections which constitute the non-sensuous or moral element in art. If so "abstract" a conception as time can be measured and divided how can it be argued that mere abstractness contradicts or excludes the proportion idea? When Shaftesbury holds that in literature, in enthusiasms, in ethical motivation and in the contemplation of nature, the chief thing is to preserve a just proportion between the self and the non-self in our affections, it may be said that his idea is fanciful, that there can be no scientific test of symmetry in mere affections; in a word, that æsthetic norms do not apply to the non-sensuous realm of experience. But wherever the notion of number or quantity may be applied there the notion of proportion is strictly applicable. A mere thought or feeling can be measured by its effect; it has (1) duration in time, (2) intensity of pitch or degree, it involves (3) the conception of parts in unity in many cases, and all these elements can be determined more or less accurately, either psychologically or physiologically. But indirectly, too, moral ideas can be measured in the objective realm by the study of historical and social institutions, and by their reflection in art.

Hence, accordingly, so far as the pleasure experienced in symmetry and proportion is the pleasure of a disinterested bystander entertained by watching the play of social forces, just so far can ethics be regarded as a branch of æsthetics, in the sense of Shaftesbury and Herbart, and moral ideas as elements

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[1] The error lies in the narrow meaning usually assigned to "moral."

in an artistic *Weltanschauung*. Indeed it is difficult to conceive of either unity or harmony in the story of creation except from some such point of view.

It is, then, a fundamental error to assume that art demands "concreteness," and then by a loose juggling with words to substitute "*sensuous*" and "offering something to the eye and ear" for "concrete." What art demands is not the "physically existing," except so far as all experience whatever has its origin in the sense stimulations, nor even the "concrete;" what it demands is the *individual*. *Its dream-object must be single and individual*, not generic. It may deal, and to be great it must deal, with the general case, but *not through class ideas as such*. *Its individual may be the type of a great class, but it must be really individual* to be artistic. Art demands a profound individualizing analysis, just like science, but it requires also an individualized synthesis, and *the most extensive type, which is at the same time the most intensive and true to individual reality*, is the greatest triumph of art. "Long ago, in speaking of Homer, I said that the noble and profound application of ideas to life is the most essential part of poetic greatness. I said that a great poet receives his distinctive character of superiority from his application, under the conditions immutably fixed by the laws of poetic beauty[1] and poetic truth, from his application, I say, to his subject, whatever it may be, of the ideas 'On man, on nature, and on human life,' which he has acquired for himself. The line is Wordsworth's own; and his superiority arises from the powerful use, in his best pieces, his powerful application to his subject, of ideas on man, on nature, and on human life." This passage is from Arnold,[2] and faithfully represents the teaching of his riper years on this most serious of literary questions. The application of moral ideas to life, he teaches, under the laws of poetic beauty and truth, is the essential distinction of great poetry. Great poets are not content to give form to matter, but they will shape a beautiful character and state, so that the race may at last rise to a level upon which the moral relations themselves may seem a means to an end.

But it must not be overlooked that Arnold defines "moral idea" in a most broad and tolerant spirit: "Whatever bears upon the question 'How to live,' comes under it.

'Nor love thy life, nor hate; but, what thou liv'st,
Live well, how long or short, permit to heaven.'

In those lines Milton utters, as every one at once perceives, a

[1]Critics of poetry often still confine "form" to metre, and show no feeling for emotional, moral, and intellectual "architectonics."

[2] Essays in Criticisms.

moral idea. Yes; but so, too, when Keats consoles the forward-bending lover on the Grecian urn, the lover arrested and presented in immortal relief by the sculptor's hand before he can kiss, with the line,

> ' For thou wilt ever love, and she be fair '—

He utters a moral idea. When Shakespeare says,

> ' We are such stuff
> As dreams are made on, and our little life
> Is rounded with a sleep,'

he utters a moral idea.''

This relation of art to morality, so much disputed by Arnold's critics, critics who share the culture of Arnold and the deep and widespread English knowledge of and feeling for great poetry, goes to the core of the problem of an æsthetic ethics. If morality deals with the whole problem of 'how to live,' and poetry gives proportion and form to moral relations, then Shaftesbury's view is sound; but if "real art" has no concern with moral relations, and other "abstract" questions, then the view still prevalent[1] (that æsthetics has chiefly to do with painting, sculpture, and architecture, and that it is frivolous to treat the "profound dissatisfaction, wholly different from æsthetic dislike, which accompanies the consciousness of guilt," as a problem of moral æsthetics), must continue to predominate.

Shaftesbury declares, and with good reason, that literature is the vestibule of his philosophy. In literature he discerned an art which concerns itself not merely with the beautiful grouping of objects of sense, but with the task of giving form, harmony, and unity to the scattered elements of human character, life, conduct and social relations, the imaginative construction of a beautiful and ideal commonwealth in which the poet should submit to the applause of humanity a conception of the life that would give established beauty of individual and racial conduct and intercourse, and reconcile the problems of freedom, communism, power, purity, and dignity, with the facts of the human body and of nature. This question has been confused by a vast amount of obscure writing, and especially by a vague and misleading use of the words *concrete*, *sensuous*, *form*, *abstract*, *moral*, by a lack of grasp of the significance of the terms *typical* and *individual*,[2] and by the uncertainty as to the value

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[1] This view is no doubt still generally held both in Germany and in the English speaking world.

[2] The typical is the sublation of individual and general, of analysis and synthesis, and it is for this reason that the character of Buddha or of Hamlet is of ethical and philosophical import.

of associated ideas in the contemplation of sensuous art objects.

The general tendency of Shaftesbury's writings is to extend the territory of the æsthetic *Anschauung* in the direction of making all nature the true art-object, of abolishing the notion of artificiality, and of including the phenomena of character and sociology in the conception of nature.

§ 2. Proportion and Ethical Motivation.

Shaftesbury never uses the word proportion without implying *an equality between real and ideal ratios.* When he declares affections to be well-proportioned, he means that certain affections bear the quantitative relation to certain others, for example, egoistic to altruistic, in real life, which they bear to each other in his ethical ideal. This usage naturally leads to the question, how does he establish this ethical ideal? The answer to this question can be gathered satisfactorily from his various works. He regards balance and symmetry as elements of good proportion which appeal *instinctively* to human approbation.[1] He regards this feeling for form as primary, and not derived from the experience or reflection of the individual. Not only are the emotions and propensities upon which morality is based, derived from the natural organization, but also the sense of form by which the affections are judged (both ethically and æsthetically at the same time) is given in the natural organization of man as we know him. But he did not stop with this idea. He regards this instinct for form as being not an artist, but an art critic; it does not say to the individual, Do this, or that, or, Do not do this, or that. The natural impulse forces the individual to do *something;* the natural feeling for proportion reports upon the goodness of the result by a simple *yes* or *no;* it does no work, it assigns no reason, it does not even say *good* or *bad* in any moral sense, but rather *pleasing*[2] or *not pleasing*, and these terms can only be interpreted to mean well or ill-proportioned.

It follows from this that this æsthetic-ethical judgment is brought to consciousness only in relation to an action founded in natural impulse, stimulated through sensation, and more or less modified by habit or reflection, and consequently it may be said to involve an application of the form-feeling to a manifestation of the stream of power flowing through the nervous system. To what extent a serious disturbance of this stream might produce "that profound dissatisfaction which accom-

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[1] In modern phrase "a beautiful ideal network." James, II, 665.

[2] There is a restful physiological reaction as if some impeded current had found its smooth course.

panies the sense of guilt," *when the organs of the body become the records of unharmonious habits or when the soul becomes disordered by passion* must be a matter partly of the sensitiveness of the nervous system. When the conception of proportion is combined with that of activity there arises not exactly a conception of form, but rather a conception of *harmony*. It is this idea which leads Shaftesbury to compare the soul to a musical instrument. The *critic* does not say whether the strings have the right form and tension until they are played upon. It is clear from this, too, that pleasure in the ordinary sense is not Shaftesbury's criterion, but the being well-tuned. The reality and agony of a discord of the soul must be thought to be quite great enough to account for the profound dissatisfaction accompanying guilt, provided that the æsthetic judgment apply to the moral world. But in reality Shaftesbury's most formidable critics hold to the vulgar, shallow view of the term æsthetic.

Accordingly, to Shaftesbury virtue is no other than the love of order and beauty in society; and this love of order and beauty in the world leads, he supposes, to belief in an orderly and artistic rule or creative principle.[1] His proof of this position is briefly as follows: The world cannot be thought of by us as a number of segregate unities, but only as a complex of related beings, in which man bears a relation more or less intimate to every other being. Virtue consists in sustaining these relations becomingly, and above all, the relations to the beings most intimately concerning us. The natural desires and needs insure intercourse among men; the love of social order is a love of harmonious natural intercourse, or flow of human activities.

Shaftesbury shows great interest in the problem of the descent of man as discussed by Hobbes, but this gives him no suggestion of inherited modifications of the mental structure; he assumes that the principal affections are inherent in the native structure of the mind. He makes a clear distinction between the intuitively necessary truths of the moral and æsthetic relations, and the knowledge of the outside world, but he expressly abandons the word "innate" (as applicable to the "Formgefühl," as a net of *apriori* relations), in favor of the word "connatural," on the ground that the precise time at which this instinctive knowledge is given can have no practical interest. He never clearly recognizes that his view of the *form instinct* requires him to assume a metaphysical theory as the basis of his system; he speaks vaguely of this instinct as indicating divinity, and yet speaks contemptuously of metaphysics, by which we may be sure he merely meant the university scholasticism.

[1] That Shaftesbury's ideas were of this stoic-pantheistic order is fully proved in Dr. Rand's recently published work.

Aside from this his attitude is that of a man of the world[1] who had attempted to form some kind of ethical *Lebensanchauung* for the endless confusion of ethical phenomena which he had encountered in reading, and in experience of life, by an application of the generalizations of *the Greeks ethics*. Two ideas became selected as the most helpful in reducing this confusion to order, (1) Aristotle's conception of *the mean*, and (2) the conception, original to Shaftesbury, of the balance of the selfish and social affections as the most comprehensive application of the law of the mean to motives of conduct. These two conceptions blended into one general view of virtue. It is true that he enumerates a third kind of affections, the unnatural, which are neither selfish nor unselfish, but merely degrading, but he makes little mention of these except in the classification, and a thorough analysis might show a certain confusion as to their exact relation to primitive altruism and egoism. He has, in general, a preference for the division of any topic into two branches corresponding to his taste for symmetry. He does not distinguish the affections which sacrifice the selfish interests of the present in favor of the interests of society, from those affections which find their own interest in the common interest, though the former alone are strict opposites of real selfishness. In fact *the social affections in Shaftesbury generally mean the alteregoistic affections.* Closely connected with this is Shaftesbury's strong inclination to consider ethics as a problem of our present life, and to treat the conception of future rewards and punishments as of merely pedagogical importance. He is intensely interested in virtue as a terrene phenomenon, and not in virtue as an abstract quality predicable of all reasonable beings.

His view, though so simply conceived, enabled him to arrange the facts of life as he saw it, with much success. To every individual there are two great facts, *self*, and *others*. The ideal attitude of character is the *symmetrical identification* of the self with the others. To incline to either side is to cause either congestion or weakness in the body politic. Even animals have social affections. Female mammals hardly distinguish their young from their own bodies. The young of the human race remain helpless for many years, hence the education of identification through sympathy makes great advances in the human race. This grows into patriotic feeling or identification with and will to die for the tribe, and even for the human race, and leads to the conception of an ideal brotherhood or republic.

[1] Students of Queen Anne's reign will find many reasons why Shaftesbury should appear less austere in his public than in his esoteric utterances, if he was to influence his age.

The love of nature, as of trees, clouds, hills, and streams, is with Shaftesbury a *higher* step in the same process, a finer and higher extension of the enthusiastic sympathy for the non-self, which he calls virtue, or the love of order and beauty in the world. All his writings agree in treating the sympathetic unification of the self and the non-self through comprehension and fellow-feeling as the essence of virtue, and this symmetry is treated as belonging to various steps, the lowest of which is that of the instinctive love of animals for their young, and the highest a poetical identification of the ego of the æsthetic consciousness with the beauty of nature. No one can read Shaftesbury's treatment of the different orders of "forms" with a free mind and not perceive that it contains the germ of Schelling's system of identity, though the germ is only a germ.

This is the sense in which Shaftesbury teaches that a love of order and proportion leads to a knowledge of the divine. The conception of a progressive refinement or culture of the affections is the backbone of his whole system; without this ground of difference between the various stadia of virtue his system would be what it has often been called, a pagan æstheticism. His pure *Anschauung* of Nature hovers on the border between the natural and the mystical, between the understanding and the spirit.[1] A character is virtuous, or has ethical form, when the knowledge and feeling of its own claims and of those of others stand in perfect balance; but both knowledge and feeling become ramified and extended from the narrow confines of a hut of primitive savages to the cosmic outlook of a modern thinker. The peculiar merit of Shaftesbury is his insistence upon balance on the various intermediate stadia. His strong grasp of this idea makes him regard goodness and beauty as identical, and this conception is greatly strengthened by the Platonic idea that perfect, or absolute goodness and beauty are identical. But while Shaftesbury has this clear view of the various stadia of goodness, and of the absolute ideal of goodness, he almost ignores the conception of *process* by which new stadia are to be reached. In spite of the great variety of his ideas, this principle of symmetry, and this lack of sympathy with what one may call broken or asymmetrical forms, go hand in hand throughout his works as the characteristic of his way of thinking. *He vindicates no special or one-sided activities*, whether in art, philosophy, conduct, literature, or religion.

It is characteristic of his view of life that he regards solitude as egoistic, and sociability as essentially altruistic. This view leads him to argue that the study of mathematics is an altruistic pursuit. He overlooks the fact that the most sinister figures

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[1] *Cf.* Kirchmann's Æsthetik. I, 54.

in history have mingled much with their fellow-men, and that the most benevolent have sometimes lived as recluses. It is evident that mathematical acumen *per se* offers no clue to the attitude of the mathematician toward society.

Shaftesbury always kept before him the conception of an ideal commonwealth, and in that sense he may be said to teach that there are not three but four classes of affections influencing human actions. Both this tendency to look *forward*, for one element of motivation, and his bold denial of the reality of evil might be treated in this paragraph, but belong more properly to the next.

§ 3. Proportion and the Good.[1]

Shaftesbury says little in his public utterances of duty as such. This conception is presented by him as a striving for harmony of conduct and of culture.[2] He seems interested mainly in the definition of virtue and of the good. The good in its various stadia is the harmony resulting from well balanced affections, or relations of the ego and the non-ego. Every form of relative good, he says, yields to a better, and all that contains mortal or corruptible elements must finally yield to the immortal and incorruptible. At every step the corruptible elements diminish, while the incorruptible increase. The road to the highest good is the middle path of virtue as defined above. The highest good is the harmony of the highest stadium of refinement and culture.

Shaftesbury is one of those thinkers before Kant who felt deeply that the world is in some way a harmony of disagreeing principles; he felt vaguely that one can stand between these contending forces, and see and feel their opposition, or rise above them and see where they meet in unity, like the meridians at the pole; which melt into unity just where they seem most to clash. When is evil not evil? When it is in a drama, for then it is only a play of the fancy, or when it occurs in a dream, for then it is all in the imagination; when we objectify our total experience, loosen the æsthetic spectator within us, and withdraw into a deeper recess of consciousness, for then we see life, the life of ourselves as well as of others as a play, or as a passing show, or as a dream of the fancy in which not only our bodies but also our souls act their parts.[3] Such is the drift of Shaftesbury's argument. This gift of sending the æsthetic consciousness outside the whole realm of experience, including our *own* joys and sorrows, and of viewing the soul and its joys and sorrows as mortal and merely imaginary is marked in

[1] The Moralists.
[2] Letters to Ainsworth.
[3] Schleiermacher—the world as art-work, and God as artist.

Shaftesbury and explains his bold paradoxes. He hovers constantly between a practical and a purely æsthetic interest in the world around him. The street is now a real street, and now an animated picture; the crowd is now a number of citizens, and now a realistic theatrical group; and now again citizens; not from doubt of reality, not from metaphysical idealization, but purely from an intense enthusiastic æsthetic feeling for form and for floating fact upon a broad, powerful stream of imaginative energy. This is the æsthetic *Anschauung* and makes evil seem merely a harmonized element in a work of art, while its mood prevails over the claims of worldly interest or every-day reality.

Shaftesbury felt this strongly, and hence arises his mixture of audacity and unsatisfactory explanation in handling the problem of evil, in which he makes naïve transitions from the position of admitting, to that of denying the reality of evil, with no apparent consciousness of their inconsistency. To the spirit at play there is no evil, but to the spirit at work there is abundant evil calling for intelligence and sympathy.

Shaftesbury repeatedly asserts that what is beautiful and well-proportioned is good, and that what is absolutely beautiful is the absolutely good. He also declares, though less directly, that what is not harmonious and well-proportioned is evil. But in spite of such assertions he is far from exaggerating the identity of the good and the beautiful, as can be seen by the following limitations: (1) He defines beauty[1] with extraordinary austerity, (2) He teaches that there are various stadia or orders of goodness and beauty, (3) He identifies moral ugliness or lack of proportion almost always with (a) excessive egoism or (b) unnatural affections. Accordingly his doctrine of the identity of goodness and beauty means simply that perfection of form is an outward indication that energy and virtue have reached a certain stadium and received the reward of striving, in the harmonious activity of the forces and affections involved. While the affections are divided the egoistic are evil; but he does not vindicate heroic altruism, and regards it as asymmetrical. *It never occurs to him that heroic self-sacrifice in the individual may tend to symmetry in the state;* hence his defective sympathy for Christianity.

Besides this discussion of evil there are three other discussions which Shaftesbury treats as preliminary to his doctrine of the highest good: (1) the meaning of the word "natural," (2) the probability of miracles, (3) the existence of God. We have

[1] The emphasis given throughout this essay to the inward stoicism of Shaftesbury is more than confirmed by Dr. Rand's contribution to our knowledge of his esoteric faith.

to do only with the influence of æsthetic ideas upon these questions.

The word natural means either governed by the instinct given primarily by nature, or governed by affections occurring in such proportions as to produce harmonious conduct on a higher plane; that is, by a refined[1] and conscious, but yet adequate, naïve and harmonious, substitute for instinct. So long as man's instinct was purely undivided and unconscious he was not really a moral being. So soon as he began to reflect upon his conduct, his instinct became divided into affections. These affections must be selfish or unselfish. Even wolves love their young and identify them with themselves to the point of dying for them. The higher stadia of life differ from the lower, not in the balance of these affections, but in refinement and self-consciousness. *Unnatural* means lacking in instinctive balance on any plane of moral conduct. On this idea rests Shaftesbury's whole structure of moral good. To Shaftesbury a return to nature does not mean a return to ignorance or savagery, but to the well-proportioned affections of instinct on new stadia of progressive refinement.

He relates the discussion of miracles to his æsthetic ideas in the following manner: All nature is a miracle; the true modern transubstantiation is the perception of a bit of nature as "*beseelt;*" at a rude blow the hamadryad may desert the tree. Shaftesbury shows a half serious enthusiasm for nymphs and hamadryads. But these Greek miracles do not disturb the order of nature. The true miracles are always present and require *not to be performed, but to be perceived.* There are minds so ill-regulated that the order of nature does not kindle the sense of divinity; these think that any violation of natural law through prodigies would offer proof of the reality of spiritual forces. But miracles, he says, though they would be proof of power would not prove goodness in the agent, and hence not God. They would unhinge nature, bring confusion into the world, break its uniformity, destroy that admirable simplicity of order from whence the one infinite and perfect principle is known. The world is, he says, not a self-governed, but a God-governed machine.

The æsthetic argument for a God he bases upon the principle that while religion cannot be founded upon a system of rewards and punishments, it can be founded upon the principle of love; and the love of God can be immediately perceived in the beauty of nature. He does not hold that every man can see the beauty of nature in this way. But great leaders per-

[1] By "refined" I mean here "sharpened" rather than *elevated* or *exalted* in the Christian sense.

ceive it and teach the race. Man's very struggle for knowledge destroys his harmony of perception, but the time will come when through adequate culture men may return to nature. He admits that while knowledge is imperfect it is impossible to prove that the universe is a harmony, but he claims that the more we learn of natural law the more reason we have to believe that nature is all governed by one spirit.

It is clear that he can have but one conception of the highest good, and he states with explicitness that to know the truly beautiful with genuine enthusiasm, and thus to achieve continuous and intense harmony is the *summum bonum*. On lower stadia proportion and symmetry are signs of harmonious affections, but the absolute beauty must be free from lower interests. "*The absurdity lies in seeking the enjoyment elsewhere than in the subject loved.*" This fine conception lies at the core of the æsthetic ethics. The psychological basis of the perception of the truly beautiful is in an affection which he calls sometimes enthusiasm, and sometime love, and which seems to coincide with the social affections in a high state of activity. Shaftesbury's ethical structure comprises a series of stadia upon which this affection seizes upon larger and larger circles of the non-ego to identify them with the ego. This process develops with increased knowledge and intercourse. It involves not only offspring, clan, country, and the human race; but finally (animals?), plants, mountains, seas, sky. When the more remote and insignificant parts of nature are saturated with this identifying sympathy it begins to be seen that the beauty of nature is literally a divine beauty, and that the soul is face to face with, if not identified with, the creative principle.

There are, he says, "three orders of forms:" (1) material forms, (2) forming forms, and (3) forms that produce forming forms, by which he says he means the procreative power. These three stadia are an æsthetic reading of body, soul, and spirit. The third order can produce minds, just as the mind itself can design material forms. That which fashions minds themselves, contains in itself all the beauties fashioned by those minds. These forms are the fountain of all beauty.

But this creative principle in man is the same which gives beauty and government to nature. It is the principle of beauty within us, our intuitive knowledge of form, that teaches us to recognize the beautiful, without instruction from others. The energy with which Shaftesbury explains that the pure attraction of beauty, an attraction absolutely *independent of the actual existence of the object* admired, must be distinguished from lower attractions, is nowhere surpassed, and is the germ of all that is best in Kant's *Kritik der Urteilskraft* and in Schiller's æsthetic letters. The highest attainable good is the harmony of the

being, involved in the perception of spiritual beauty through sensuous representation. The idea is essentially one of freedom. It can hardly be said that Shaftesbury taught an Identitätssytem, yet it is mainly, perhaps, his aversion to metaphysical speculation that kept him from making the step thereto. The creative energy in man occurring on the most refined stadium of culture, freest from narrow interests, finds itself in complete harmony with the creative principle in nature, showing as the beautiful. The world is thus perceived as "*beseelt.*" There is no desire to see it other than it is, to perform miracles, because there is no possibility in this state of any *desire* of any kind whatever; harmony is precisely the condition in which desires are at rest. The soul perceives the divine beauty of the world and assents to its goodness. What is not seen as perfectly good is not seen as *beseelt* and harmonious. This is to see the miracle of creation and in a sense to see it from the point of view of creator; but this state of mind can hardly be called moral, inasmuch as it occurs at a point where the consciousness withdraws from interested relations.[1] Shaftesbury considers the human form as a part of nature, and as its most beautiful object. It was from him that Schiller took his idea of the difficulty of seeing the human body æsthetically.[2] In the *Moralists*, where he expresses so passionately his feeling for the spiritual beauty of nature, he confines himself to the beauty of landscape, because he knew that it requires almost superhuman elevation of mind to treat the human form as a pure æsthetic phenomenon. This passage was the key-note of the chorus of nature-poetry that began a few years later with *The Seasons* and which has been a main element in literature ever since. Shaftesbury's influence on Pope's verse[3] has been elaborately exploited, but his influence on Thomson, Cowper, and Wordsworth is far more important to us. Shaftesbury's connection of the highest good with a pure and intense *Anschauung* of nature and with the third or creative order of forms in man is full of suggestiveness, and foreshadows another problem of æsthetics, that is, the relation of beauty to sublimity on the highest stadium of appreciation. It is true that Shaftesbury speaks of nature thus perceived as beautiful, but the discrimination of beauty and sublimity was but ill-understood by Burke many years after Shaftesbury death (1761), and was not understood in the modern sense before Kant's definitions (1790). Shaftesbury expressly states that the sublime places of nature, great forests, mountains, caverns, are most favorable to the contemplation of God. In this,

[1] Neither *immoral*, nor *not yet moral*, but *prœtermoral.*
[2] Letter 26.
[3] Paul Vater.

as in many other respects, he foreshadows modern æsthetic views.

It becomes clear upon reflection that nature, seen as the immediate expression of divinity, cannot be called beautiful without at the same time being called sublime. In spite of certain differences between the definitions of Kant, Hegel, and Vischer, on the one hand, and of Fechner, Hartmann and others on the other hand, there is a general agreement that a sublime object must in some sense be great or mighty (*gewaltig*), that it must arouse a sense of fear and weakness in the spectator, and that this feeling must be followed by a pleasing sense of the superiority of mind over matter. (It seems that the tragic in the moral world arouses fear and pity in the spectator, but also gives pleasure by being perceived in the æsthetic *Schein*. This analogy has sometimes led to a slight confusion between the terms *tragic* and *sublime;* Shaftesbury uses the word sublime rather of conduct than of sense-objects). Kant teaches that, in the sublime, perceptions are not compared with conceptions of the understanding, as in beauty, but with ideas of the reason. Its effect depends, therefore, upon a *disproportion* between sense-perceptions and ideas of reason. The German Æsthetik in general derives the sublime from the "Vernunftidee des Unendlichen." There seems to be a great deal of[1] *relative sublimity* which does not quite arouse those ideas of the soul which we call *unendlich*, or absolute, or divine; but certainly the sublime is most effective when it does so affect us. (Ex. Coleridge's *Hymn to Mont Blanc.*)

On the contrary, the beautiful, instead of exalting the spiritual part of man and humbling the sensuous, brings a feeling of harmony and proportion between the sensuous and the reflective powers of our nature.

Hence, accordingly, it would seem that Shaftesbury's beauty of nature is not mere beauty: (1) because he views the whole earth, mountains, oceans, sky, with a comprehension of their enormous magnitude and power, (2) and because his contemplation ends in a referring of all this to a spiritual being. But on the other hand all these sublime elements are seen by Shaftesbury as a vast and *beautiful* harmony, while *the sublime as such is always characterized by a certain isolation*,[2] and, short of its solution in catastrophe, a certain *insolubility*. Can an object be both sublime in the strict Kantian sense, and beautiful at the same time? The answer to this is that before an object can really be perceived as (absolutely) sublime and (absolutely) beautiful at once it must arouse in the spectator a har-

[1] *Cf.* Karl Groos, Einleitung in die Æsth. S. 310.

[2] Just as the tragic is characterized by loneliness, as in Hamlet, Macbeth, Timon.

monious perception of spiritual powers which *wholly* satisfies the aspirations of the intellect at the same time, and this could only mean that the object is known by a mind which perceives the sense object as a spiritual creation (or in other words by an intuitive intellect in which will and power are one, and the understanding a mere channel of communication). Shaftesbury probably does not strictly mean that the harmony between his soul and the *sublime beauty* of nature amounts to a sense of creation, but merely that it offered a presentiment of such a sense. Or if he *really* believed that he perceived the soul of nature in the beauty of the landscape, it is yet possible that this belief was the error of an enthusiastic, sensitive, and aspiring mind. The efforts of poets to see the world from this imaginary point of view frequently lead to poetry in which a high degree of beauty and a high degree of sublimity are more or less successfully blended. (Ex. Faust I. Prolog. in Himmel, V, 1-28.)

It follows from this that the highest good, as taught by Shaftesbury, is an æsthetic delight in nature, including man; in this state beauty on its highest plane forms a union of sublime elements, and the attitude of the beholder is that of an artist rejoicing in his work with a full critical appreciation, but with no thought of *merely* understanding it or fearing it, but of taking an ecstatic pleasure in it. In the progress of the æsthetic consciousness toward such an ideal, it is clear that the sense of sublimity must extend enormously before all objects can be received into an æsthetic *Anschauung*. It is probable that as knowledge increases and sensibility keeps pace, not only mountains, oceans, storms, are regarded as sublime, and not only the earth as a vast ball in space, but even small and hitherto insignificant objects which science has discovered to be examples of great natural laws. The *feeling* that should be inspired by natural law comes very slowly, yet both knowledge and feeling are implied in any progress toward freedom.[1] *In the days of Kant the view of sublimity which prevailed in literary circles was crude if not vulgar from our point of view.* Many parts of Schiller and Byron which thrilled our ancestors leave us cold. The average literary student of to-day in England or America accepts Matthew Arnold's estimate of Byron and Wordsworth as substantially correct,[2] though the Germans still regard Byron much as the English did long ago. Some modern poets find sublimity in objects that were once thought mean and trivial, and the tragic is no longer confined to the great and powerful, and indeed, in some instances, has been seriously extended to the fortunes of animals, if not of plants.

[1] Knowledge and virtue are identical only when knowledge includes the feeling which belongs to it.

[2] *Trent* on the Byron revival—but he does not refute this view.

Sympathetic identification of the self with the non-self follows, slowly, upon the searching analysis of scientific investigation, and begins to construct a spiritual, but not a superstitious, *Weltanschauung* nearer to that which presented itself to the insight of Shaftesbury.

Shaftesbury's view of the identity of the supreme good and the supreme beauty resembles that of Plato in many respects.[1] But Shaftesbury's clear and original grasp of the necessity for balance between and sympathy between the self and the non-self brings him very close to the present age. He may be said to stand midway between Plato and Schelling.

§ 4. Proportion and Enthusiasm.

Shaftesbury deals with three chief points concerning enthusiasm in its relation to proportion: (1) What is the nature of the quality called enthusiasm? (2) What is enthusiasm in the derogatory sense? (3) What is it in its best sense?

He made a highly original effort to see a mysterious psychological phenomenon in a reasonable and philosophic light. He considers enthusiasm both from an ethical and from a metaphysical standpoint (*i. e.*, in its relation to reality), and makes an attempt to comprehend both views under the category of æsthetic form.

Shaftesbury takes the conception of enthusiasm very seriously. He uses the word partly in its Greek sense (*ἐνθουσιάζειν*), and partly in its relation to those terrible outbreaks of religious mania which were so widespread in the middle ages.[2] Hence the mysterious suggestiveness of the word in this essay. In no case does he employ it in its usual modern English sense.

In the *Moralists* enthusiasm is spoken of as a *sense* by means of which the "divine beauty" of nature may be apprehended; that energy through which nature may be perceived in the æsthetic *Schein* as understood by Shaftesbury, who as a student of Plato (v. Rep. Bk. X) had grasped that conception as firmly, though not as analytically, as Schiller and Hegel. In the *Inquiry* he has based the conscious moral activities in the animal affections. While these are below the state of reflection they are neither moral or immoral, but non-moral or submoral. In the moral realm they show normally (he speaks also of unnatural affections) as selfish and social.

Enthusiasm may be described as a state of the soul in which the animal energies, acting on various planes of consciousness, urge the individual to extraordinary activity of body or mind. When this extraordinarily energetic impulse reaches a very

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[1] Republic, VII, 517.

[2] *Cf.* Dancing Mania of Middle Ages.

high plane of consciousness it produces, perhaps, a knowledge or power which the understanding does not possess, such as the power of perceiving nature through æsthetic intuition as "*beseelt.*"

Enthusiasm in general implies a preponderance of natural energy over culture with a consequent lack of repose or stability. If the mind is cultivated adequately in many directions it makes a reasonable use of the energy supplied it by nature in the performance of its ordinary functions. On the other hand, if the mind has few or fragmentary lines of thought, and yet is supplied with a great flow of activity, it is always in danger of being roused to fury by the rush of superfluous energy into some complex out of which it cannot find a way for itself. The tendency of this impulse to discharge itself in action makes persuasion of no avail, because the outlet offered by any suggestion of reason is too slight to give relief.

Hence enthusiasm may be said to be bad when it occurs in relation to a notion not standing in well-proportioned relation to other notions. Humor is a peculiarly effective means of drawing off the energies of a fanatic or a mob from their fixed ideas if employed in good time.

The Greeks had enthusiasm with well-proportioned culture. Their *Weltanschauung* was broad and complete; though their knowledge was not minutely ramified, yet it was comprehensive, and was crowned by a mythology in which the muses gave them a *provisional or fanciful outlet toward reason*,[1] which though poetical was sane and natural. Aristotle and Kant do not take their categories more seriously as a set of meridians toward truth than Shaftesbury takes the Muses as guides to the Elysium of the æsthetic *Anschauung*. The Christians, he says, pity the Greeks, but their religion as humorless, fanatical and "soul-saving," is inferior in symmetry, naturalness and breadth. God, he says, with naïve anthropomorphism, is to be conceived not as severe, pompous, imposing, but as sweet and good-humored. Ill-humor is the result of narrow culture, or of opposition, but God can have no ill-humors, for in him all the energies get their appropriate play, and he is not opposed.

Enthusiasm, accordingly, is good when it produces an energetic, well-balanced activity in ordinary minds, and it is best when it, through natural power and well-balanced habits of associational thinking rises above the mere intellect to the energy of poetic genius, of artistic inspiration, or spiritual intuition.

In this essay on Enthusiasm, Shaftesbury shows a lack of

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[1] This is a main use of great poetry.

appreciation for the sublime, the individual, the tragically persistent, the inadequate but struggling idea. He has a vivid conception of what is harmonious for mankind or for a single fortunate and cultured person. But he never grasps the greatness of a man or a nation with a mission, a peculiar and divine vocation; hence his bitter contempt for the Jews as one-sided gloomy fanatics, and his preference for the joyous Greeks. He quotes with fine literary effect the saying, "though I give my body to be burned and have not love, it profiteth me nothing," but fails to see that *in the community*, "form" can be achieved only by self-sacrifice. To love the public, to study universal good, and to promote the interest of the world by making our best views prevail, is, he says, "that temper which we call divine." But this temper of making the good prevail must, he insists, be "*unbiased*," because otherwise we cannot "judge the spirits whether they be of God." His dislike for vulgar enthusiasm is a distaste for bad form. His dislike for an intimate personal religion, a "soul-saving" religion, is a disgust for bad manners. Shaftesbury, like Plato, had a remarkably strong grasp upon the simple principles of form, such as symmetry, proportion, unity. But it would be easy to overestimate his artistic gifts, for he shows little sense of structure as a prose writer, and his notions of art are the notions of a *thinker*, with no convincing sense of individual reality. He has a strong artistic impulse, but little physical basis for it, and no technical training. With convincing sensuousness, and training in observing and handling the individual case, he might have been an artist; for the enormous respect for form and art, which he continually displays, is not more remarkable than his taste, energy, and sensibility, his insight into character, his sympathetic humanity, and his impassioned love of truth and justice; all characteristics of the greater artistic or poetic temperament.

One might say that he had a horror of that sublime enthusiasm which, with some narrowness, but great singleness of purpose, has no thought of beautiful form in any relative sense, or on any lower plane than its particular "kingdom of heaven," but pursues the infinite and absolute in severe and disciplined striving. Shaftesbury was all in favor of broad, joyous, well-proportioned solidarity. Yet in his own inward life the beautiful in all its fullness reached the sublime level, and like his Greek masters he believed that he perceived not the shadow but the reality.

In Shaftesbury's last writings[1] enthusiasm is related to melancholy and even in a sense to sublimity. But melancholy is

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[1] Miscellanies.

pathological, and the true sublime is not tragic melancholy, but a feeling of serene divinity ("There is a power in numbers, harmony, proportion, and beauty of every kind, which naturally captivates the heart, and raises the imagination to an opinion or conceit of something majestic and divine)."

This *right enthusiasm* shows as (1) the courage of the true soldier, and (2) the genius of the artist, (3) it is the means of perceiving the really beautiful, (4) it is the spiritual element in sexual love, and (5) the flame of *pure friendship;* (6) through it, *religious feeling* becomes "an astonishing delight or ravishment."

The *false enthusiasm* takes the form of fear, melancholy, consternation, suspicion, despair, and, above all, superstition, belief in evil spirits, and experience of morbid and degrading religious ecstasy.

His most fruitful new application of the idea in his last work is the suggestion that history may be regarded æsthetically. In Greece life was well-balanced, and beauty was generally worshipped. But when Rome came to rule, the power of that terrible empire tended to raise "an expectation of a divine deliverer." This conception is endlessly suggestive of the analogies between psychology and history; it is in striking accord with the æsthetic theory of the relation of the sublime to the terrible, and with Schelling's view of history. Taken in connection with his conception of the highest good as a sublime-beautiful *Anschauung* it would suggest that in an ideal commonwealth the Christian sublimity of spiritual power would be combined with Hellenic proportion and harmony.

His general doctrine regarding enthusiasm is that it is the *power* of the human mind, and that it is capable of almost any kind of results, depending upon the *direction* and *proportion* it receives from the reason; a means for complete slavery or perfect freedom. This enthusiasm he regards as the activity common to body, soul, and spirit, and he makes a vehement appeal for the view that form is a conception strictly applicable to the inner experience. His view is, that no matter how much knowledge and energy society may have, it can never have freedom and harmony until all the parts of its achievement are related in a well-ordered form. Harmoniously related *form* is the æsthetic contribution to ethics.

§ 5. Proportion and Literature.

Shaftesbury conceived that the function of literature is to show in a pleasing form a true image of the world, and especially of the relations of character and conduct. To treat the world of moral relations as material for artistic form by giving it expression in particular persons and situations is to be a lit-

erary artist. But this can be done well only by one who has a comprehensive sympathy for his fellow-men. *To identify one's self through imaginative sympathy* with all kinds of persons, to see the world as one's self, and to judge it as one judges the corresponding phenomena in one's own character, is to have the literary point of view. But to be an artist of conduct and character one must be self-critical. Our true genius or guardian spirit is our æsthetic consciousness retreating into the distance in order to judge the composition of our own soul, and "according as this recess is deep and intimate" we can see ourselves truly and obtain that knowledge which fits us to judge others wisely. Shaftesbury's position is as follows: The body is the seat of pleasure and pain, the soul, of hope and fear, joy and sorrow, etc., etc. The consciousness may be more or less fully identified with either body or soul; but the consciousness may withdraw from its immediate locus in either body or soul without, however, failing to do justice to the comparative reality of either; in this recess the consciousness is the literary bystander; the æsthetic spirit. It sees the world of passion in its own soul, but does not particularly distinguish its own soul from the souls of other human beings because through sympathy it holds their joys and sorrows to be equally related to it.[1] This point of recess is the center of all human experience; the artistic spirit knows the joys and sorrows of the race not less but more deeply than the practical consciousness, but it perceives individual experience, whether in its own case or that of others, to be part of an harmonious masterpiece.

The question has often been raised, why do we take pleasure in tragedy, and why is the pleasure great in proportion as the pain is great. Kant's teaching of the sublime shows how the painful becomes pleasurable when referred to the infinite. Shaftesbury's view is very broad, and may be stated as follows: from the deepest recess of the æsthetic consciousness not only the terrible and tragic, but *all the phenomena of body and soul* appear to have only *imaginary reality*, and the deep pleasure of the æsthetic *Anschauung* is in the sense of power and harmony which arises from unifying and transcending experience, while not ignoring its comparative reality, but rather most fully recognizing it.[2] Only from this point of view can one know the world truly, all others are unfree and onesided. Poets, lovers and mystics, he says, aim at seeing the world imaginatively, but they often lack the deep and well-rounded self-knowledge demanded for the task. This is Shaftesbury's

[1] The contemplation of a play should not excite the *will*, except in boors.

[2] "He that will all the treasure know 'o the earth, must know the center too." Shakespeare.

idea of proportion applied to literature as it has been already applied to virtue, the highest good, religion, and philosophy. This inner architecture, he says, must be applied not only to the character, but to society. We are to seek the moral Venus as distinguished from the sensuous. We are to use our sense of æsthetic form to improve our moral proportions, and this improvement will, in turn, improve our sense of form. Shaftesbury has always before him the conception of an ideal commonwealth where all will be beautiful and good, and the image of this state, as conceived by the poet, should be an incentive to progress. "Such a poet is indeed a second maker, a just Prometheus under Jove." He holds that only poets of just character can produce beautiful ideals, "for knavery is mere dissonancy and disproportion." He even thinks that music must have done much to promote civilization by setting up an idea of harmonious relations.

Even in art he dreads the discordant effect of selfish interest. Any workman who loves his work as such, and is proud and independent regarding reward, is a true artist,[1] and this spirit of idealism and æsthetic joy in the daily work, he declares is "real virtue and love of truth! independent of opinion and above the world!" In the same vein he praises Shakespeare because he pleases "without a single bribe from luxury or vice." He is far from advocating that literature should teach morality, he does not want moral purpose but ideality—beautiful moral proportions. "It is a due sentiment of morals which alone can make us knowing in order and proportion, and give us the just tone and measure of human passion."

It is because he thinks literature a good basis for ethics that he thinks it a better discipline for a philosopher than metaphysics. Literature is worthless when it is "Gothic or barbarous," by which he means lacking in design or unity of design. "Nature," he says, "cannot be mocked," that is, all that is ill-ordered must quickly disappear.

Accordingly, in literature as in other matters, it is only the regularly beautiful that appeals to Shaftesbury; not the striving for deeper spiritual content regardless of regularity of form as in the pictures of Dürer, but the repose upon an achieved stadium of perfectly formed beauty and perfectly adequate expression as in the works of Raphael. Yet Shaftesbury desired the highest degree of spiritual content. But he did not like those great transition movements by which what he esteemed the highest ornaments of literature are reached. He is not impressed with the tremendous complexity of the problem of transitition from stage to stage of æsthetic and ethical forms,

[1] Bosanquet's Æsthetic, 452-3.

or of the relative values of those masters who have and who have not symmetry and proportion.

In his latest utterances he shows a deepened sense of the truth that proportion has new significance as the social relations widen. This is observable in his remarks on patriotism as an ethical form midway between egoistic-family and egoistic-race affections. From his new point of view he seems to rank the egoistic-fatherland affections first of all. This agrees with his general moderation of opinion.

These are problems intimately related to literature and ethics. His conception of manners and morals as the same thing on different planes has also something fresh and interesting as indicating his tendency to see patriotic and cosmic affections as an expansion of the narrower forms of alteregoism, as shown in love, family, and party relations. Had he been given to metaphysical speculation he might have come to regard metaphysics as an egoistic universal form analogous to patriotic and race interests but more expansive still. When he says "to philosophize is to carry good breeding a step higher," he utters a half-symbolic truth about good form, very characteristic of his standpoint.

Another later thought is his application of good form to pedagogy, and though he says little, the topic is suggestive of the enormous importance of natural form in the complex associated ideas of youth, and of the danger of abstract, fragmentary, and inadequate ideas. He represents the English notion that balance and manners are the object of education. The teaching of this system inculcates honor rather than goodness or learning. It may be safely asserted that all specializing in single branches would have seemed to him dangerous, as tending to congestion and lack of balance. He favored those studies, such as music, poetry, history, etc., which tend to develop the mind all round. He identifies proportion with health and beauty. He does not see that harmony on higher stadia may be favored by sacrifice of harmony, or "that we should things desire that do cost us the loss of our desire,"[1] and yet desire rightly; hence, as was said in another connection, his defective sympathy for heroic Christian ethics.

§ 6. Common Sense and Proportion.

Sensus communis, says Shaftesbury, is not good sense, so much as the good *feeling* resulting from a fair and just view of the rights of all men.

In religion the opposite of common sense is a gloomy asceticism which despises the world and allies itself with the super-

[1]Two Noble Kinsmen, V.

natural. In philosophy nothing is more opposed to common sense than the doctrine that man is by nature entirely selfish. In the course of the argument he declares that "it is the height of wisdom to be rightly selfish." It is manifest that common sense is another name for Shaftesbury's social affections; a term, as has been shown, which he uses not in the sense of altruistic, but of alteregoistic affections.

His arguments in favor of common sense are: (1) Friendship is admitted on all hands to be an intensely human quality, no ridicule of which is tolerated by the race. Yet this quality is eminently alteregoistic; that is, a matter of give and take: it is the virtue of a joyous and natural people. (2) Poets and musicians show in their love of harmony, and in their desire to please and benefit others, that they are filled with *common sense*, and they are accordingly accepted by common consent as true human types. (3) Lovers are regarded by all as natural human types, yet no true love is merely selfish. (4) The beauty of women also lies in a mysterious sympathetic expression which indicates the opposite of the selfish and sensual qualities which Hobbes and others regard as natural to humanity. (5) Even in war it is a mistake to regard humanity as merely selfish and wolfish. The soldier is a wolf toward the enemy, but nowhere else are so many acts of splendid self-sacrifice and tender devotion to be found as in the relation of the soldier to his comrade and his home. The coldest men are the slowest to take sides. (6) To be truly cultured is not to be selfish, but to have a fine and broad sense of proportion. Shaftesbury uses the humorous argument that if Mr. Hobbes had not been desirous of helping the race he would never have taken the very serious risks that attended the publication of his heterodox books.

Shaftesbury's view is that a normal man will do no wrong *and take none*. His argument is not against a full measure of selfishness, but against injustice. The natural conclusion is that a man of sense claims his rights, and that he who does not is "too good." To be perfect is to be well-balanced. To renounce one's rights does not seem right to him. He makes no distinction between the individual and the state.

This grave fault in the system has been dealt with by Butler and many others from the ethical point of view. *But the defect is just as marked from the æsthetic side.*[1] Shaftesbury continually speaks of the contrasted affections without observing that both classes struggle from plane to plane. A man may be unselfish about food, clothes, and pomp, precisely because he is selfish about others matters, such as scholarship, or fame. A

[1] Æsthetic ethics has suffered from Shaftesbury's error regarding the need of symmetry in individuals; it must be admitted that he was wrong before a satisfactory form can result.

prophet or religious leader may despise not only material, but also intellectual rewards because of a selfish desire for spiritual knowledge and power, visions, prophecies, ecstacies, miracles. It is evident that balance upon any of these planes would give an adequate and powerful ethical form *so long as the form remained unbroken by the ideas of new desires.* But the number of such planes of conduct is infinite. A man leading an intellectual life reaches a seemingly satisfactory form or set of opinions about life, in which his ideas and energies are balanced and connected, and lead to appropriate actions. But a new idea[1] rouses scepticism, doubt, hesitation; thought and action get out of joint, and the form is no longer adequate for naïve and healthy activity. Without these sceptical suggestions, often the promptings of ambition, there would be no rupture of well-proportioned views, but there would also be no progress in refinement and expansion of ethical forms. Shaftesbury, who is keenly conscious that only the pure spiritual *Anschauung* is the finally true form (the "third form" of the *Moralists*), often fails to apply this necessary conception when praising *mere lateral symmetry* of affections. He sees clearly that there are three principal forms, material, mental, and "divine," but *he has no feeling of the broken paths that lead from the one to the other;* no grasp of the value of *the comparatively formless*, of the *process* as distinguished from the result, of the sprouting as distinguished from the fruit. Eccentric affections, pathos, tragedy, individuality, sublimity, are obscure to him. Yet his answer to Hobbes is essentially sound. His attitude is somewhat as follows: an animal must be selfish, but it must also be good to its own; man, as a moral being, who rejoices and suffers, thinks and feels, may be selfish, must be selfish, but the really human and natural type must sympathize *with as much as he makes his own.* If Hobbes replies, yes, but the motive is his own good in some sense at last, Shaftesbury rejoins that in the refined type the ideas of *meum* and *tuum* fade into a harmony through sympathy, and hence, selfishness, which is essentially a notion of opposition, division, and number, is completely overcome in a sense of family unity. There can be no selfish element in the contemplation of the universal beauty because that state of mind depends upon a sympathetic identification of the self with the whole world.

Common sense is accordingly the conception of a *disinterested humanity*, and this may be described as the form which the æsthetic *Anschauung* assumes in social relations. This is Shaftesbury's conception of *natural*, and gets strong support

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[1] *Cf.* Faust I, "Erhalte dich und deinen Sinn
In einem ganz beschränkten Kreise."

from the consideration of the *impartial* attitude of the artistic mind in general, as, for example, that of Shakespeare, whose interest in humanity is at once free and intense. Common sense is the knack of living harmoniously in relation to the general surroundings, both material and moral, and the great literary character possesses this quality in the highest degree, though literary genius lacking in breadth is often conspicuously eccentric.

§ 7. Proportion in Conduct.

Two points are clear from a general study of Shaftesbury's letters:[1] (1) That his style is more simple and intimate, less rhetorical than in his essays; and (2) that he is more severe in his condemnation of sensuality than he thought wise to say in his published utterances.[2] As a result of this greater sincerity we learn a little more about his ethics. The two chief points regarding morals, so far as we are concerned with his ethics in this treatment, are (1) that he recommends to Ainsworth as a rule of conduct the views of his own system, and (2) that he gathers the Nichomachean doctrine of the mean into a simple synoptical form in which all cases of conduct are reduced to four or five.

(1) His advice to Ainsworth may be summed up in the phrase, "Seek for the καλόν in everything!" This advice is given more specifically in the following forms: (a) In philosophy avoid extreme subtlety, and imitate rather the popular style and method of Locke; (b) In religion, be moderate, and above all be tolerant; (c) In literary style be simple and unaffected; (d) In reading be broad and impartial; (e) In the conduct of life be neither a sensualist nor yet a too unpractical idealist; (f) In social relations be neither selfish nor lacking in ambition, (g) Cultivate the body as a means of freeing the mind; (h) Avoid public controversy, but seek all means of self-criticism.

All this is summed up in the sentence, "Dwell with honesty, and beauty, and order; study and love what is of this kind, and in time you will know and love the author:" and in another place, "Seek and find out the true *pulchrum*, the *honestum*, the καλόν: by which standard and measure we may know God." Carefully proportioned striving is the rule of culture; this is beautiful conduct; the perception of divine beauty lies at the end of this vista; this is the highest good.

(2) In all his works (and particularly in the 8th letter of this series) Shaftesbury insists upon the sense of proportion as

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[1] The private letters.

[2] He desired to influence the 18th century society, not as a prophet, but as a man of the world.

instinctive or "connatural," and not derived from experience. He declares that the approval of beautiful form comes from an instinctive capacity, and is not learned. Like Plato and Aristotle he regards the form faculty as the essential mental principle. He admits that this may remain unconscious until an object is presented to the senses. He does not, like Kant, attempt to show the grades or steps that lead from the simplest forms in space and time to more complicated phenomena. He is interested not in metaphysics but in ethics, though his antagonism to Locke sometimes brings him near to epistemology.

Shaftesbury's idea of an ethical form may be resolved into five fundamental elements: (1) Egoism, (2) Altruism, (3) Sensuality, (4) Spirituality, (5) Proportion. The notion of proportion applied to a just balance between selfish and unselfish affections, runs all through his work. The notion of balance between the sensual and spiritual is found chiefly in these letters: (1) in the warnings against pleasure, sloth, intemperance and the sins of the flesh; and, (2) in the warning that there is a sort of spiritual ambition which unfits a man for life, and lacks reality.

The most remarkable feature of his work here is that *he never falls into the ethical fallacy of confusing altruism with spirituality, or egoism with sensuality*, but takes these four as *cardinal points of his form*. Altruism and egoism are two elemental and equal forces in nature, they are the forms which instinct takes in the relations of individuals, and when refined by experience they combine again in spiritual power. When they are unequal in the individual the individual lacks balance, common sense, naturalness, (a bitch that eats her young is "unnatural"). Perfection requires two kinds of balance which one may designate as *lateral*, that is, between the contending forces of the parallelogram of social forces, namely, egoism and altruism, and *vertical*, that is between the animal appetites and the spiritual desires. We may connect this vertical balance with Plato's conception of the lower and higher souls, and with the Catholic denunciation of such sins as gluttony and sloth and adultery. But vertical balance is not more essential than lateral balance, and this conception aims at the sins of greed and ambition, and is the peculiar moral ideal of socialists, philanthropists, and the poor. An ethical form requires, then, the unification through harmonious proportion of (1) the animal lusts, (2) the spiritual aspirations, (3) the selfish, and (4) the unselfish affections.

With this simple conception of ethical form Shaftesbury unites the idea of *progress* through labor and study. Hence his conception of form leads to a conception of forms on various planes, the highest wheel touching the supersensible world.

The letters to Ainsworth in no way recommend heroism or martyrdom as a wise rule of life, but rather sense and tact.

§ 8. Proportion and Art.

Shaftesbury spent his last days in Naples. He busied himself chiefly with the study of art. He made designs for pictures which he paid an artist to execute. Some of these are engraved in his works. *The Judgment of Hercules* is an essay on one of these. It is coldly allegorical. The didactic predominates over the æsthetic interest, and the piece is neither true to nature nor naïvely mythological or symbolical. Though not more distinctly allegorical and moral than many famous pictures, it quite lacks the fire and sincerity and technique that redeem works like Dürer's *Melencolia*, and Hogarth's *Rake's Progress*.

Shaftesbury's limitations in this field do not tend to prove that a fine sense for moral truth is not part of the equipment of a great artist, but rather that *such knowledge must be carried, so to speak, in the blood*, and not crystallized into maxims.

The picture in question is a kind of miniature of his whole view of life. Hercules is allured toward a pleasant glade by Venus and attracted toward a temple on a hill, toward which a steep road runs, by Minerva. Sensuality and selfishness draw downward and backward, and are opposed by spiritual ambitions and self-sacrifice. Yet Hercules is not less interesting to humanity because his will is determined only after a struggle.

Art, as Shaftesbury saw it, was a mirror of these great human passions and impulses, and beautiful because of the just proportions in which each type of character and situation is reflected. Beauty to him lay in the equilibrium of these warring elements. His views had influence upon the next generation of painters—the generation of Hogarth, Gainsborough, and Reynolds.

Conclusion.

This study, from an æsthetic point of view, leads in general to the submission of the following estimate of the chief points in Shaftesbury's ethics:

1. Proportion, symmetry and related æsthetic notions are applicable to moral phenomena.
2. These æsthetic notions depend upon the native structure of the mind, and constitute our moral sense.
3. Virtue consists in preserving a due proportion in the affections: it produces harmony and happiness.
4. The identification of selfish and social interests may occur on any of the planes of culture between animal and spiritual life.
5. The highest good is harmony on the highest plane of cul-

ture, consists in a pure enjoyment of the beauty of all nature, and demands stoical perfection.

6. The highest beauty is sublime and beautiful at once.

7. Evil may be seen to be imaginary by a retreat of the consciousness into the place of an æsthetic bystander.

8. Enthusiasm is genius or fanaticism according to its proportions.

9. "Natural" means symmetrical in relation to egoism and altruism, on whatever level of culture. Common-sense is nature on a middle level.

10. Literature demands self-knowledge through observation and sympathy.

11. The beauty of art depends on a harmonious equilibrium of contradictory (moral) elements.

The striking defect of Shaftesbury's exoteric ethics is not any exaggeration of the value of æsthetic form, but a lack of recognition of those evolutionary activities which oppose form and destroy harmony on one level to lead to form and harmony on a higher level: as, in art and literature, tragic earnestness attacking unsolved problems of conduct and fate; in religion, a certain fanaticism; in morality, self-sacrifice; in learning, specialism; in conduct, martyrdom; and, in general, eccentric and solitary activities. He understood *adequate* but not *provisional* forms.

A GENETIC STUDY OF RHYTHM.

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CHAPTER I. PROBLEM AND METHODS.

§ 1. *Problem Stated and Defined.*

One of the most recent writers on rhythm[1] has affirmed that "Es gibt keinen schlechten Rhythmus." In other words, the perception of rhythm is present in completeness or vanishes entirely. This appears to be the opinion of the majority who have discussed rhythm,—either actually expressed, or implicit in their general presuppositions. But are there not well marked stages of relative perfection and complexity in the perception and production of rhythm?

The present Study is an investigation of this question with respect to one field of motor rhythm, that of rhythmical speech. Are all rhythmical forms equally simple psychologically; can the trochee and iambus, for instance, be regarded as equally difficult? Moreover, is any one verse-form constant and unalterable in structure; does it not also show different degrees of completeness and unitariness? *E. g.*, is the dactyl as produced by the young child as complex in structure as that produced by an older child; do the same objective variants appear in both cases; and do they bear the same relations to each other? Or, again, to put the question more concisely; can a correlation be made out between growth in complexity of the rhythmical form produced and mental grasp the producing subject?

There has been no attempt in what follows to bring the stages of this progressive growth in complexity of structure into connection with the history of the different metrical forms; for, in the first place, psychology has no concern with metrical questions as such; and, secondly, we have no more right to argue from the present psychological data back to an hypothetical past consciousness, than from that past to the present. Factors unknown to the present consciousness were undoubtedly effective in the past; and such factors would naturally vitiate any deductions drawn.

In the investigation of our main problem other questions arose, which seemed to demand special attention. These have been separately treated. They are: (1) the nature of pitch as an objective determinant of rhythm; its direction and constancy as compared with that of the temporal and intensive factors; (2) the relation of breathing to the spoken rhythm; (3) the conditions under which concomitant movements appear; and (4) the influence of chorus reading upon tempo,—a comparison of chorus-time with the average times of the individuals.

The present Study cannot be termed genetic in accordance

[1] Rhythmus und Arbeit, Margaret Kiever Smith. Phil. Stud., XVI, p. 292.

with the usual signification of that term, which emphasizes the concept of origins. But it is genetic in a secondary or derived sense; for it seeks to determine the essential constituents of rhythm, and the variations they undergo in the development of the more complex from the simpler forms.

The genetic theories have been chiefly concerned to explain the origin of rhythm. They have been content, as Meumann[1] justly says, to furnish an opportunity for the entrance of the rhythmic consciousness, but have made no attempt to analyze the psychological and physiological mechanism of this consciousness; all this they have taken for granted.

Such theories have, as a rule, relegated the working of the causal principle to the remote past. Hence they are not only safely entrenched against the criticism which experimental and introspective facts might seem to warrant; but they are also unable to appeal to introspection or experiment for support. Consequently, genetic theories of this type must depend upon historical data for their verification. Even when connected with metrical investigations they can never have greater weight than that which is accorded to speculative hypothesis. Even the recent interesting investigation of Bücher has the defects common to genetic theories[2] of the type mentioned.

The genetic method, as it is here used, has its chief value in the solution of the problems offered by the psychological complexes themselves. Rhythm, for the adult consciousness, is so interwoven with associations of all sorts; is such an unitary and unanalyzable experience; that it is well nigh impossible to disentangle the essential from the non-essential constituents. But we can hope, through a judicious use of the genetic method, to reach a more satisfactory analysis of the objective constituents,—temporal, intensive and qualitative—and of their relations to each other; by correlating these with increase in ability to attend and to apperceive we can also hope to show more clearly the intrinsic nature of rhythm.

The danger of false interpretation of such data is greater than it is in the case of adult psychology. This is due to the tendency of all observers to read their own experience into the observed phenomena. The experience of an observer is naturally farther removed from the child's than from that of another adult. Neither can observations in this case be verified by the introspective report of the subject, as in the problems of adult psychology. But with carefully collected data, and conservative interpretation, the danger can, we think, be reduced to a

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[1] Untersuchungen zur Psych. u. Æsthetik des Rhythmus, Phil. Stud., X, p. 252.

[2] Arbeit und Rhythmus, Zweite Aufl., Leipzig, 1899.

minimum. The investigation of Bolton[1] sought in another way, *i. e.*, by the study of subjective rhythmisation, to reduce the problem of the psychological constituents of rhythm to its simplest terms. While this method gives us the simplest conditions under which grouping may occur, it cannot show the relation of the simple or subjectively conditioned rhythm to the more complex and objectively conditioned.

§ 2. Method.

The age of the subjects—children of the first, fourth and seventh grades—determined the method. It was necessarily objective,—a study of their ability to produce the different rhythmical forms.

Those who have worked with children know that the normal child is incapable of introspection. Even if an occasional child might be able to give introspective data, these would have slight scientific value; for every sign is caught at, as a suggestion in accordance with which a report may be given. The answers returned to the simple question of 'what form pleased them most' were contradictory in so many cases, that from the answers given by sixty children at several different readings not enough reliable material was obtained to base a single conclusion upon.

The investigation has been confined to the spoken rhythm. It was desired later to test children of the same age on the ability to tap the same forms. The time, however, failed for this, except in the case of several particularly unrhythmical subjects. Thus a satisfactory comparison of the two forms of motor rhythm, which would be highly desirable, cannot be made. The experiment was performed in two ways. (1) A successive number of readings were given by a comparatively large number of children. An analysis was made by the experimenter during and immediately after the production of each form. (2) The same forms were given by three children; a girl of seven, and two boys of nine and eleven respectively, and the Rousselot microphone was used for analysis. The first series of tests was made on both German and American children; the second on American alone.

Method I. The children serving as subjects were taken from the Zentral-Schule and Sanderschule of Wuerzburg, and the Central and Grammar Schools of Ithaca. They were on the whole normal children, neither exceptionally bright nor exceptionally dull. The teachers were requested to select five boys and five girls from each of the three grades before mentioned. They were to give, in their selection, as great variety of temperament as their school afforded,—the plodding and faithful student as well as the careless and listless,—but were

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[1] Rhythm, *Amer. Jour. of Psych.*, VI.

it a rhythmical whole as well as to see if any one form of grouping appeared more frequently than others. Consequently, words which already possess a primary rhythm, and verse with its complicated rhythms, could not be used. It was also necessary to employ the *same* syllable, in order to avoid all inequalities in the articulation.

It might be objected that deductions cannot be made from the grouping of such material as this to the grouping of verse. To this it may be replied that, in so far as the primary rhythm governs verse, the same principles hold as in the grouping of these simple meaningless elements. It is the modifications introduced by what Sidney Lanier[1] terms secondary and tertiary rhythm, *i. e.*, the rhythms of word-accent and thought, that change the primary rhythm, giving verse its special beauty and flexibility. Moreover, in the experiment with the American children of the fourth and seventh grades, the syllables were frequently involuntarily modified so as to read *meet* me, me, or *meet* me, thus introducing a secondary rhythm.

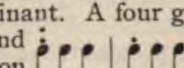
Method II. From the American children, subjects were chosen who had taken part in the previous experiment. The method was modified by using the Rousselot microphone. The record of the rhythm was traced on the drum of a Ludwig-Baltzar kymograph; synchronously a breathing curve was registered. For this the Harvard pneumograph, adjusted around the chest, was connected with a Marey tambour. The time was marked in fifths of a second by a Jaquet chronometer. The Rousselot microphone consists of a metallic mouthpiece connected by a rubber tube with a cylindrical metallic box in which three carbon tips are suspended. The adjustment is made by means of a screw at the end of the box opposite the junction with the tube. The screw, through its connection with a metallic spring to which one of the carbon tips is attached, regulates the distance between the tips. The wires connecting the tips with the electrical circuit enter through the top of the box. In the same circuit is a small electro-magnet, above which is a drumhead of goldbeater's skin, to which is attached a writing point. The changes in the current of air entering through the tube make and break the current. The intensity of the sound is indicated by the amplitude of vibration of the writing point; the pitch by the number of vibrations in a given unit of time; the duration of syllables and pauses by the length of the records and the length of the intervals. It was found necessary to use a more explosive syllable than *me*, and *be* was substituted as being nearly equal in time. The microphone responded with the greatest precision when the level of the

[1] The Science of English Verse, N. Y., 1888.

mouthpiece was slightly below the mouth of the child. The children stood as before. The number of syllables was not limited, as in the previous experiment. All of the involuntary series were taken first, then the complex groupings in varied orders. Though the microphone responded as readily as could be expected, the restrictions of position, etc., decreased the child's sense of freedom; concomitant movements were very seldom marked, while none of the zest that had been shown in the previous experiment was observed. Each method had its peculiar advantages and disadvantages. The chief advantage of the second was that it furnished an accurate record of the rhythm as it was given. The disadvantages were that with fewer children there was less variety in form, and that individual characteristics might easily be confused with general. The feeling of restraint that attended the use of the microphone could not be eliminated, and militated against a natural grouping. The experiment was regarded as a task, while in the earlier experiment the children gave themselves up freely to the swing of the rhythm. As already shown, the first method had the advantages of a freer rendering on the part of the children and greater possibilities for variety in form; its disadvantage was that, as we possessed no objective control, there was liability of error in the analysis of the experimenter. But this liability to error in analysis was counterbalanced, in a measure at least, by the facts that for many of the series two experimenters were present, and that a large number of observations were made. The second method, then, can be considered as a control of or check upon the first.

CHAPTER II. RESULTS.

§ 1. *Involuntary Grouping.*

Results from Method I. The series were separated by intervals of a week. The first series were given before the children had learned the complex forms; but the practice of the previous week had doubtless some influence upon the succeeding series; this reached its height in the third series. Later, probably because of the monotony of the work, there was a return to the simpler forms of the first series. The order of succession, regularity or irregularity in the occurrence of a pause, is the primary objective determinant. A four group form divided into twos occurred twice; and  was noted once; otherwise, with the exception that the end of the line was frequently marked by a longer pause and a falling voice, the three-grouping was the largest observed. We will note first those cases, in which the syllables varied neither in time, intensity nor pitch, although differentiated by the regu-

lar or irregular occurrence of a pause. The results can be tabulated under four rubrics: (*a*) no observable regularity in the occurrence of a pause; (*b*) pauses after each syllable of equal duration; (*c*) pause after every second syllable noticeably longer than the intervening; (*d*) the longest pause after every third syllable.

TABLE I.

Irregular pauses.			After each syllable.			After every 2nd.			After every 3rd.			
Gr. I.	Gr. IV.	Gr. VII.	Gr. I.	Gr. IV.	Gr. VII.	Gr. I.	Gr. IV.	Gr. VII.	Gr. I.	Gr. IV.	Gr. VII.	
2	4	6	9	3	9	0	2	2	0	0	0	G. B.
19	18	23	19	18	22	19	18	22	19	18	23	
2	3	5	2	0	0	0	1	23	0	0	0	G. G.
15	20	25	15	20	25	15	20	25	15	20	25	
3	5	0	3	6	2	7	2	2	1	1	0	A. B.
22	22	18	22	22	18	22	22	18	22	22	18	
4	1	0	0	4	3	6	7	5	1	3	1	A. G.
22	22	19	72	22	19	22	22	22	22	22	19	

G. B. indicates German boys, G. G. German girls, A. B. American boys, A. G. American girls. It was impossible to obtain exactly the same number of readings from each class; for, on the appointed day, one or even two of the five children might be absent, and nothing remained but to proceed with the experiment: hence the results are given in fractional form, the numerator representing the number of occurrences, the denominator the total number of readings.

In the first case all perception of rhythm failed, although the rate of reading was sufficiently rapid for rhythmical grouping to have occurred. The irregular cases are distributed through all the five series. Had the irregularities been due to a difficulty in the articulation of the syllables, we should naturally expect that practice would cause its disappearance in the later series. Another peculiar fact is that the number of irregular cases is greater among the upper grades of the German children than among the lower. This, in the light of the fact that movements regularly repeated tend to become automatic, would seem to show that the irregularities in this case cannot be explained on the ground of irregularities in motor adjustment. The most plausible explanation is that the series did

not possess sufficient interest to hold the attention, and that the irregularities in the rhythm were due to the irregular pulses of attention.

In case (*b*) we have what Miss Smith terms "einfachen" or "Urrhythmus." "Es ist keine Frage dass auch in der blossen Aneinanderreihung von völlig gleichbetonten Silben, zwischen denen keinerlei Gruppirung mehr hergestellt wird, ein Rhythmus liegen kann. Ebenso kann eine Zeile eines Liedes in lauter ganz gleichen Noten voranschreiten, und doch rhythmisch sein. Diesen Fall bezeichnet die Verfasserin als einfachen oder Urrhythmus."[1] This Lanier calls "primary rhythm."[2] "If equal or simply proportioned intervals of time be marked off to any of our senses by any recurrent series of similar events, we may be said to perceive a primary rhythm through that sense." "But this primary rhythm may be considered a sort of primordial material, which the rhythmic sense of man always tends to mould into a more definite, more strongly marked, and more complex form that may well be called secondary rhythm."

There is no apparent correlation between age and the appearance of this form in the free reading. The cases are fairly equally distributed among the grades. The pronunciation of each syllable was frequently accompanied by a forward movement of the head or of the whole trunk. With the first grade children, when attempting to produce an anapæstic or dactylic form, a lapse into the primary or uncompounded rhythm was often noted. A frequent peculiarity of such cases was a regularly recurring pitch, time, or intensive difference, together with pauses of equal duration at the end of each syllable. It was doubtless due to a breaking down of the complex group in which certain characteristics of the complex form were still retained. These cases throw light on the mental processes underlying rhythm. The most plausible explanation of the phenomenon seems to be that one wave of attention did not take in the total group, so that each single syllable was the object of one act of attention. Although the different syllables were still compared as to time, intensity, etc., it was a mediated comparison of the same nature as that performed by the adult in his comparison of the several groups of a long series. This transition from immediate to mediate comparison could have been brought about either by the slow rate of succession, or by the too great span of the group as to number, or by the intrinsic difficulty of making a comparison; any one of

[1] *Op. cit.*, p. 198.
[2] *Op. cit.*, p. 62.

these three factors would have brought about the result. Wundt[1] denies that this alternate series of syllable and pause, movement and rest, attention and inattention constitutes a rhythm. "Gleiche Eindruecke in gleichen Pausen stattfindend wirken ermuedend, aber niemals rhythmisch. Damit ein æsthetisches Gefallen entstehe, muessen mindestens zwei verschiedene Eindrücke, Hebung und Senkung des Klangs, wie in 2/8 Takt, in regelmaessigem Wechsel einander folgen, mag nun dieser Wechsel durch die Eindrücke selbst oder bloss durch die subjective Betonung erzeugt werden." In this passage, the term 'rhythmical' clearly connotes capability of arousing an æsthetic feeling. This seems to be an unwarrantable limitation of meaning. If æsthetic value is to be made a criterion of rhythm, then frequently the complex forms must be regarded as unrhythmical; for there are not a few instances in our own experiments, as well as in those of others, in which a form possessing all the objective marks of a highly complex rhythm and evidently perceived as such was either subjectively indifferent or positively unpleasant. The feeling of æsthetic pleasure is too subjective a criterion to apply to such an objective and universal fact as that of rhythm. In the present paper, rhythm is used to cover all cases of regularly recurring impressions derived from the modalities of audition and movement.

The first step toward an unification of the separate impressions is that noted in cases (*c*) and (*d*). Here two or three syllables of equal duration, pitch and intensity, are separated from those following by intervals noticeably longer than the intervals between the given syllables. This form was characteristic of the free reading of the seventh grade boy by Method II; *cf.* record for Charles, Method II, involuntary grouping. It scarcely appeared in the reading of the German children. When there was a rhythm, there was generally a subordination of one syllable to another, by means of pitch, intensity, time, or a combination of these. The form shown in case (*d*) was far less frequent than that of case (*c*). Many of Bolton's[2] subjects found difficulty in throwing auditory sensations into groups of three; our own (*cf.* results on pitch) never grouped in threes unless there was an objective ground for so doing. The form shown in case (*c*) frequently resulted when the younger children attempted to give the more complex rhythms. This form was also characteristic of the free readings of the two negro children, a boy of the first and a girl of the fourth grade. For the hearer, their reading was very rhythmical. The time values

[1] Grundzüge der physiologischen Psychologie, 4e Aufl., 1893, II, p. 237.

[2] *Op. cit.*, p. 216.

for these series were greater than those for the irregular and the primary forms. We may presume, then, that the syllables were given their original length, and that the interval between successive pairs was considerably lengthened. One wave of attention could compass the group, and no attempt was made to compare syllable with syllable. These results do not tally with the generally accepted rule for the subjective grouping of auditory sensations, which affirms that there is no tendency to group successive sounds until some one is heard as more intensive than the others. Have we here a purely physiological phenomenon, which has no parallel in sensation; in other words, is such a series perceived as rhythm, or is there merely a rhythm in the motor mechanism? The result might have been the outward expression of the natural breathing rhythm, the expiration lasting during the two syllables and the intervening pause; but such a curve, as will be seen in the discussion of breathing, is not the normal rhythm of respiration. There is another possible explanation. It is that, although the syllables presented equal difficulties for the organs of articulation, etc., and there was nothing in the nature of the syllables themselves or the child's attitude towards them to raise one in importance above another, there was, nevertheless, a tendency present towards the unification of the large number of separate syllables, by their division into a number of smaller groups. Several syllables fell within one pulse of attention, and the pause which corresponded to the zero-point of the attention wave was consequently longer than the intervening pause. Meumann and Bolton dealt only with the grouping of auditory sensations. Doubtless in that fact is to be found a partial explanation of the disagreement in results; still (*cf.* the section on pitch) subjects frequently broke up series of equal sounds into groups of two, four, six, eight, etc., syllables, without giving any one more intensity, duration or pitch than other. There was, according to their statement, no recurring intensive difference to cause the grouping for the perceiving subjects. These cases were interspersed among series that differed objectively. The conditions here would seem, then, to be more favorable for a correct analysis of the perception of rhythm than they were in the experiments of Bolton. For here the series which had no objective mark of difference lost in subjective intensity in contrast with objectively conditioned rhythm.[1]

The breaking up of the series of separate impressions into groups of two or three equally accented syllables was an ad-

[1] One of Miss Smith's subjects found in learning nonsense syllables that "der Rhythmus der Betonung spielte keine so grosse Rolle wie Gruppirung oder Theilungen." See *op. cit.*, p. 256.

vance upon the primary rhythm; but the group lacked unity. The manner in which a closer grouping was effected varied with the individuals, and there were also indications of race difference; but regular temporal, intensive, and qualitative variations were the objective factors. The longer, higher and louder tones occurred together or were used interchangeably. Meumann discusses the interchangeability of time and intensity in the estimation of time intervals under the principle of "Stellvertretung."[1] The accent, intensive, temporal or qualitative, was given as shown in the Table. Accent is used throughout as synonymous with emphasis, and is not restricted to increase in intensity.

TABLE II.

Qualitative.			Intensive.			Temporal.			
Gr. I.	Gr. IV.	Gr. VII.	Gr. I.	Gr. IV.	Gr. VII.	Gr. I.	Gr. IV.	Gr. VII.	
6	9	3	0	2	1	1	1	2	G. B.
19	18	23	19	18	23	19	18	23	
10	16	15	0	5	5	0	6	6	G. G.
15	20	25	15	20	25	15	20	25	
2	3	2	3	7	6	5	5	5	A. B.
22	22	18	22	22	18	22	22	18	
5	2	1	3	6	5	4	4	5	A. G.
22	22	19	22	22	19	22	22	19	

G. B. indicates German boys, G. G. German girls, A. B. American boys, A. G. American girls. The numerators give the number of occurrences, the denominators the total number of readings.

The most noticeable fact shown by the Table is the greater number of cases of qualitative accent among the German children. The pitch intervals were also as a rule greater than with the American children. The number of accented readings, intensive, temporal and qualitative, was greater among the German girls than among the German boys. Both American boys and girls of the seventh grade gave accented readings more frequently than the German boys of the same grade. There were a greater number of irregular readings given by the German boys of the seventh grade than by the younger children.

[1] Beiträge zur Psychologie des Zeitbewusstseins. Phil. Stud., IX, pp. 303 ff.

Cf. with this result, Table I, above. There seems to be a curious contradiction here. Other things being equal, the irregular readings disappeared with increased age, and one might reasonably expect to find an increased tendency to accented grouping among the older boys; but the explanation given in the account of irregular readings doubtless holds here.

It is a question how much a conscious imitation of the complex forms had to do with the manner of free reading. We discovered it in the case of one of the American boys of the seventh grade. When questioned he admitted that he was purposely giving a certain form because it pleased him. Even after throwing out such cases, which were not frequent,—knowing the characteristics of children, we were able to detect any such distortions,—there is a noticeably greater tendency toward a strongly accented rhythm in the free readings given by the older children than in those given by the first grade. The first syllable was almost invariably the accented syllable; the reverse occurred but three times among the American children and twelve times among the German.

Results from Method II. To avoid the influence of the complex forms upon the natural grouping, all the involuntary series were taken first. This order would have been followed in the first instance; but the children would then have taken no interest in what, from their point of view, would have been a stupid and meaningless task. For this reason it was necessary to ask for the restrained and free readings on the same day. But the microphone presented difficulties enough to make the desirable arrangement possible, and yet preserve the interest of the children. On the other hand, the use of the microphone was too difficult to be accompanied with much pleasure.

R. A. Girl, first grade, self-controlled to an unusual degree, susceptible to rhythm. The figures given are the averages of the absolute time values of the successive series. Pitch was uniform throughout, and the intensities varied but slightly, and only in the manner indicated in the Table. Type of grouping was clearly primary, uncompounded, occasionally irregular. Series (3) will be discussed in detail as it has an important bearing on the genesis of the complex rhythm.

We note that the time of both syllable and pause falls within the most favorable time for rhythmical grouping (.5 to .2 second). The grouping falls under either the irregular or the primary type, with the exception of Series (3). The breathing record is interesting in this connection. Each syllable corresponds to an expiration, each pause to an inspiration; *i. e.*, a full inspiration was taken after every syllable. (*Cf.* breathing records.) This type of breathing was characteristic of *R. A.*'s reading, restrained as well as free.

TABLE III.

	Syllable.	Pause.	Intensity and Pitch.
Av. values for series in sec.	(1) .408	.458	No variations in pitch or intensity.
	(2) .298	.454	Intensities of the syllables equal; each syllable begins with greater intensity and then gradually grows less; no variation in pitch.
	(3) .282	.346	Important for genesis of rhythm. *Cf.* discussion following.
	(4) .463	.39	No variations in intensity or pitch.
	(5) .287	.45	" " " " " "
	(6) .332	.4	" " " " " "

Series (3) was taken on the same day as (1) and (2); the microphone was working unusually well. *R. A.* began with the primary form; suddenly we heard a marked change in her manner of reading. It was trochaic. Nothing that we could observe had occurred to bring about the change. We could only refer it to the ease with which she was reading, and the practice that series (1) and (2) had given her; although in the free readings following she never reverted to this type. It is also to be noted that at the same time in which the rhythm became trochaic the breathing curve was compounded; *i. e.*, expiration lasted during the interval occupied by two syllables and the intervening pause. The complete results are given for this series. The breathing record is paralleled with that for the spoken rhythm. The variations of amplitude of vibration within the rhythmical unit at no time exceeded 1 mm.; therefore only the relative deviations in intensity can be given.

It is probable, had it been possible to make the estimations perfectly exact, that the slight deviation between the time for the breathing and the spoken rhythm would disappear. It is to be noticed that compounding in breathing occurs before there is any evidence of a grouping in the spoken rhythm, but that immediately thereafter the second syllable becomes shorter and less intensive than the first, although the intervening pause is fully as long as that following. Next, the second syllable is shortened and the pause following it is lengthened. This markedly trochaic grouping lasts in its most perfect form, as shown in the * groups, for only three groups; following upon this, there is either no difference in the length of the pauses, or an unvarying intensity, *i. e.*, a less perfect grouping. While we cannot conclude from this one record that it presents the exact order in which a complex grouping is brought about, it clearly gives a possible genesis, and shows how closely related breathing and grouping are. There is no evidence as to which

TABLE IV.

Breathing Record.			Spoken Rhythm.		Pitch and Intensity.
Exp. sec.	Insp. sec.	Height mm.	Syll. sec.	Pause sec.	
.419	.233	1.5	.35	.337	
.466	.166	2	.325	.35	
.5	.266	2	.3	.325	
.5	.33	2	.3	.4	
.466	.266	1.5	.375	.325	
.6	.233	1.3	.45	.275	No variation in pitch or intersity.
.4	.283	3	.325	.4	
.466	.33	2	.275	.325	
1.566	.33	2	.325 (*a*)	.4	
			.35 (*b*)	.35	
.966	.45	2.25	.3 (*a*)	.4	
			.125 (*b*)	.325	Intensity of (*b*) less than that of (*a*).
1.016	.316	.266	.425 (*a*)	.175*	
			.125 (*b*)	.525	" " " " " " " "
1.66	.316	2	.4 (*a*)	.175*	
			.25 (*b*)	.4	" " " " " " " "
1	.316	2.25	.35 (*a*)	.275*	
			.225 (*b*)	.4	" " " " " " " "
.95	.35	2.75	.25 (*a*)	.375	
			.15 (*b*)	.5	" " " " " " " "
1.03	.266	2.5	.25 (*a*)	.35	
			.225 (*b*)	.425	" " " greater than that of (*a*).
1	.283	2.75	.375 (*a*)	.275	
			.175 (*b*)	.45	" " " equal to " " "
1.16	.3	3	.25 (*a*)	.35	
			.175 (*b*)	.215	" " " less than " " "
1	.3	3	.45 (*a*)	.175	
			.2 (*b*)	.425	" " " equal to " " "
1	.316	2.25	.5 (*a*)	.175	
			.2 (*b*)	.425	" " " " " " " "
.85	.33	2.33	.375 (*a*)	.2	
			.2 (*b*)	.4	" " " " " " " "

stands in the relation of cause and which of effect unless priority of compound breathing might be taken as an indication that change in breathing was the cause of the grouping. It is more probable that the change in breathing was due to some psychical factor which may in turn, enforced by the breathing, have brought about the decided grouping. The state of *R. A.* at the time of the record was evidently one of pleasurable interest in a not too difficult activity. There was a pendular movement of the whole body, such as was seldom marked in the experiments with the microphone, although found very frequently in the readings given by Method I. One might venture, then, to posit as a cause for the grouping the fact that the attention was directed upon the series as a whole and not upon the articulation of each separate syllable.

H., a boy of ten, fourth grade; restless and incorrigible in school; while interested in the experiments, was unable to direct his attention long upon any one thing. (The first three series of the free readings were given by a boy of another type; but he was not available later, and *H.* came to the laboratory in his place.)

TABLE V.

	Syllable.	Pause.	Pitch and Intensity.
Av. values for series in sec.	(1) .588	.136	No variation in pitch or intensity.
	(2) .363	.13	
	(3) .573	.175	
	(4) .35	.276	
	(5) .442	.191	
	(6) .488	.173	
	(7) .402	.192	

The pauses are invariably shorter than in the reading of *R. A.* The relative times have changed. While in *R. A.*'s reading the syllable and pause varied but slightly in duration, in the reading of *H.* the pause is much shorter. There is scarcely any variation in the duration of the several pauses. The rhythm is throughout of the purely primary type.

The breathing was very different from that of *R. A.*; an expiration lasted on an average for eight syllables, although as few as five and as many as ten were at times included in one expiration. The inspiration was short, corresponding to the longer pause in the spoken rhythm. The grouping was also of the same general form; series of five to ten syllables, varying very slightly as to time and not at all as to intensity or pitch, were separated by short pauses and followed by a longer pause, varying in length from .3 to .5 second.

C. D.; eleven; seventh grade; leads his class; very painstaking.

TABLE VI (*a*).

Primary Rhythm.

	Syllable.	Pause.	Pitch and Intensity.
Av. values for series in sec.	(2) .57	.158	No variations in pitch or intensity.
	(3) .548	.142	
	(7) .75	.137	

TABLE VI (*b*).

Two Grouped Rhythm.

Syllable.	Pause.	Pitch and Intensity.
(1) (*a*) .59	.084	No variations in pitch or intensity.
(*b*) .56	.163	
(5) (*a*) .565	.1	
(*b*) .532	.181	
(6) (*a*) .7	.102	
(*b*) .69	.221	
(7) (*a*) .555	.075	
(*b*) .495	.138	

The breathing was of the type already mentioned in the case of *H*. There were none of the irregular fluctuations which appeared in *H*.'s reading. While pitch and intensity held the same throughout the series, there was a slight tendency to a two-grouping in series (1), (5), (6) and (7). In these series the first syllable of the group was slightly lengthened, as was also the pause at the end of the second syllable; *i. e.*, they approached the trochaic type. In the other series, the larger groups which corresponded to the breathing rhythm were made up of an irregular number of syllables, seven, nine, or eleven. The separate syllables varied but slightly in duration. They were examples of the primary rhythm. On the whole, *C. D.* shows a greater tendency to rhythmical grouping in his free reading than does either *H.* or *R. A.* of grades four and one.

It is apparent at a glance that the results gained by Method I gave a greater variety in manner of grouping; pitch and intensive differences were there frequently present, whereas here they fail entirely, except in series (3) for *R. A.*, which showed slight intensive variations.

The reason for the disparity between the results of the first and second method can be accounted for as follows. (*a*) The practice with the restrained or complex groupings exerted an influence on the free readings of the succeeding week, in the first experiment; (*b*) with the microphone, there was a certain constant resistance to be overcome; this tended to bring about an automatic regularity and uniformity in the articulation of the syllables, and the result was the primary form; (*c*) the resistance of the microphone was so great that attention was directed upon the articulation of the syllables. The freedom and spontaneity that characterized the readings, as given by Method I, were entirely wanting. This would militate against the perception of rhythm. Miss Smith points out similar in-

stances.[1] "Obgleich (beim einfachen Rhythmus) in diesen Versuchen die Bewegungen des Aussprechens taktmaessig waren, hat die Versuchsperson wegen der Schwierigkeit desselben keinen Rhythmus irgend welcher Art empfunden. Die ganze Aufmerksamkeit wurde auf die Qualitaet der Leistung gerichtet, und wie vorher bei den Gewichts-und Schreibversuchen entstand auch hier die Empfindung des Rhythmus erst dann, wenn eine gewisse Gewand theit gewonnen worden war." (*d*) According to the arrangement of Method I, the syllables were written in five lines of six syllables each. As they thus stood, they were more readily divided into groups. One of Miss Smith's subjects reported that, as he readily divided a visual series into groups of three, so three syllables made for him an unity easily perceived. This may also have been a factor which helped to bring about the divergences in the results of our two Methods.

Summary.

1. An involuntary grouping may arise either through a regular variation in time relations, or by regular intensive or qualitative variations. The earliest form, in order of priority, seems to be the primary; following that is the two-grouping with equal syllables, but regular variations in the duration of the pauses; then comes the two-grouping by means of temporal, intensive or qualitative subordinations among the syllables. 2. The temporal subordinations are the first to appear in involuntary grouping; intensive or qualitative changes come later. 3. Grouping increases in completeness with increased development of the child. 4. There seems to be a tendency in the motor mechanism toward automatic regularity which furthers the production of rhythm. 5. Breathing appears to stand in a functional relation to the rhythm. 6. Involuntary grouping occurs (*a*) when the attention is directed upon the series as a whole; (*b*) when an incentive is present to lighten the work or perception by separating the total series into smaller and easily perceived groups. This equal division of attention (in pulses of natural length) gives the double guarantee of a perception of all the members of the series with a lightening of the work of perception. (*c*) When a regularly recurring activity tends to bring about a rhythm in the motor mechanism; (*d*) when there is no feeling of bodily discomfort or strain to distract the attention. 7. Grouping disappears (*a*) when the effort of articulation is so great that attention is necessarily directed upon the act itself; when, *i. e.*, the attention is abstracted from the succession to the individual members; and (*b*) when the time equivalent to the normal pulse of attention is exceeded by the total duration of two syllables.

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[1] *Op. cit.*, pp. 233, 254, 290.

§ 2. Voluntary Groupings.

For the sake of convenience, the results are given in the order: trochaic, iambic, dactylic, anapæstic groupings, although, as before stated, the order was constantly varied during the course of the experiment. The terms trochaic, iambic, dactylic and anapæstic are not used in the metrical sense, but as convenient terms for forms of restrained groupings of two and three syllables, in which a certain syllable of each group is emphasized. Grouping was, however, never mentioned; it arose naturally and involuntarily from the regularly recurring emphasis.

Method I. As in the free readings, the judgments of the experimenter were only relative; *i. e.*, one syllable was judged longer or louder than another. We attempted to note pitch differences exactly. While it would have been desirable to note time and intensity differences under the three categories of just noticeably present, present, and marked, we found that the distinctions had not been and could not be accurately enough made, in every case, to warrant such a classification. Notice was also taken of the position and character of the pause, the presence or absence of concomitant movements and their general character, together with the time for the whole series. The concomitant movements and time values of the different forms are discussed in a later Section.

Because of the unequal number of readings in the different classes, Tables of presence and of absence have been given. The distinctive differences in the readings of the three grades are clearly brought out by a comparison of these two Tables. In the case of qualitative differences, 'marked' designates intervals of a fourth or more; 'inverted' signifies that the falling inflection occurred, where the rising is ordinarily given, or *vice versa*, or that the relations of long and short were reversed, etc.

Total for Five Series of Trochaic Readings.

Table VII (*a*).

Pitch Variations. (Present.)

I.	IV.	VII.	
15 p. 3 m. 1 i. 0 ir.	10 p. 7 m. 0 i. 1 ir.	10 p. 10 m. 1 i. 2 ir.	G. B.
17 p. 0 m. 0 i. 1 ir.	10 p. 9 m. 3 i. 0 ir.	17 p. 3 m. 3 i. 0 ir.	G. G.
4 p. 0 m. 1 i. 0 ir.	12 p. 2 m. 0 i. 0 ir.	12 p. 2 m. 0 i. 0 ir.	A. B.
7 p. 1 m. 1 i. 0 ir.	16 p. 2 m. 0 i. 0 ir.	13 p. 0 m. 2 i. 0 ir.	A. G.
43 p. 4 m. 3 i. 1 ir.	48 p. 20 m. 3 i. 1 ir.	52 p. 17 m. 6 i. 2 ir.	Total.

p., signifies present; m., marked; i., inverted; ir., irregular.

TABLE VII (*b*).

Pitch Variations. (*Absent.*)

I.	IV.	VII.	
0	1	1	G. B.
1	1	2	G. G.
16	8	4	A. B.
14	3	4	A. G.
31	13	11	Total.

(1) The tendency of the German children toward a qualitatively determined rhythm is shown more clearly in the Table of absence than in that of presence; but this difference between the German and American children decreases with increasing age. (2) Intervals of a fourth or more occur more frequently among the German children. (3) Cases of inversion were scattered through all the series; the voice-fall being falling-rising, instead of rising-falling, as generally found in trochaic grouping. Inversion in pitch is not a function of age.

TABLE VIII (*a*).

Intensity Variations. (*Present.*)

I.	IV.	VII.	
7 p. 4 m. 0 i. 0 ir.	11 p. 4 m. 0 i. 0 ir.	18 p. 2 m. 0 i. 0 ir.	G. B.
6 p. 2 m. 1 i. 0 ir.	8 p. 7 m. 0 i. 0 ir.	14 p. 3 m. 0 i. 0 ir.	G. G.
3 p. 0 m. 0 i. 0 ir.	18 p. 0 m. 0 i. 0 ir.	9 p. 4 m. 0 i. 0 ir.	A. B.
10 p. 2 m. 0 i. 0 ir.	16 p. 2 m. 0 i. 0 ir.	15 p. 2 m. 1 i. 0 ir.	A. G.
26 p. 8 m. 1 i. 0 ir.	53 p. 13 m. 0 i. 0 ir.	56 p. 11 m. 1 i. 0 ir.	Total.

TABLE VIII (*b*).

Intensity Variations. (*Absent.*)

I.	IV.	VII.	
8	4	3	G. B.
6	8	7	G. G.
18	4	5	A. B.
10	3	0	A. G.
42	19	15	Total.

It was often difficult to distinguish between a slight rise in pitch and a slight increase in intensity. Repetition was then required.

The dissimilarity between Germans and Americans is not so marked as in Table VII. The first grade Americans are distinctly less rhythmical than the German children of the same age. The correlation between increased intensive variations and increased age is even more marked than the same correlation in the case of pitch. Inversion is far less frequent in intensity than in pitch.

TABLE IX (*a*).

Temporal Variations. (*Present.*)

I.	IV.	VII.	
4 p. 0 m. 0 i. 0 ir.	9 p. 1 m. 0 i. 0 ir.	14 p. 0 m. 0 i. 0 ir.	G. B.
3 p. 1 m. 0 i. 0 ir.	7 p. 4 m. 1 i. 0 ir.	14 p. 3 m. 1 i. 0 ir.	G. G.
4 p. 0 m. 0 i. 0 ir.	20 p. 0 m. 0 i. 0 ir.	10 p. 4 m. 1 i. 0 ir.	A. B.
13 p. 0 m. 1 i. 1 ir.	13 p. 2 m. 0 i. 0 ir.	9 p. 7 m. 2 i. 0 ir.	A. G.
24 p. 1 m. 1 i. 1 ir.	49 p. 7 m. 1 i. 0 ir.	47 p. 14 m. 4 i. 0 ir.	Total.

TABLE IX (*b*).

Temporal Variations. (*Absent.*)

I.	IV.	VII.	
15	9	9	G. B.
12	11	7	G. G.
17	2	3	A. B.
8	6	1	A. G.
52	28	20	Total.

(1) Increased tendency toward temporal subordination in grouping runs parallel with increase in mental development; the difference between the first and fourth grades, in this respect, is greater than that between the fourth and seventh. (2) There are numerous cases of inversion. These arose through prolongation of the last syllable into the time of the pause. Inversion here, as elsewhere, does not seem to be a function of age; it is even more frequent with the older children. (3) The effect of practice is greater upon the German children; with them there was a marked increase of temporal and intensive differentiation in the fourth and fifth series, and a corresponding increase in the unity of the grouping. In the case of the American children, the rhythm of the third, fourth and fifth series showed scarcely any deviations from that of the first.

Are there closer relationships existing between any two of these objective factors than between the others? When the rhythms are not determined by all three, temporal, intensive

and qualitative, which two appear most frequently together? An answer to this question would throw light upon the subjective nature of these objective factors. The results have been tabulated to show these relations.

TABLE X.

P. and I. present together.			T. and I. present together.			P. and T. present together.			
I.	IV.	VII.	I.	IV.	VII.	I.	IV.	VII.	
9	5	6	0	0	0	2	1	0	G. B.
7	8	2	0	0	2	1	2	2	G. G.
1	0	1	1	5	3	1	2	1	A. B.
1	5	0	2	3	3	0	2	0	A. G.
18	18	9	3	8	8	4	7	3	Total.

P. T. and I. present together.			P. T. and I. absent.			
I.	IV.	VII.	I.	IV.	VII.	
2	9	14	17	9	9	G. B.
3	8	14	12	12	9	G. G.
0	11	9	22	11	9	A. B.
8	13	14	14	9	8	A. G.
13	41	51	65	41	35	Total.

The mediation of the grouping through variation in pitch and intensity alone appears frequently among the Germans; it is less noticeable in the upper grades, as all three factors are there more often present. A *T-I* grouping is more characteristic of the Americans; while a grouping mediated by *P* and *T* seldom characterizes the German or American reading. This would seem to indicate that pitch cannot be a complete substitute for intensity, but rather serves to heighten the effect of an intensity variation. *Cf.* the discussion of pitch, for the relations between pitch and intensity.

The rhythm certainly gained in richness of content and unity of impression with increase in years.

Pause.—Unfortunately for the results, as to the relation of the pause in the group, the observations on German children are incomplete. The position of the pause was noted only in very striking cases; consequently, a satisfactory basis for comparison with the results obtained from American children is wanting, as absence or presence, regularity or irregularity, was noted here in every reading.

TABLE XI (*a*).

Position of Pause. Americans.

(Results for boys and girls given together.)

I.	IV.	VII.	
44	44	37	TOTAL NUMBER OF READINGS.
8	4	4	Pause after each syllable.
29	40	33	Pause after every second syllable only.
—	—	1	Pause after third syllable only.
12	1	1	Absent or irregular.

TABLE XI (*b*).

Position of Pause. Germans.

(Results for boys and girls given together.)

I.	IV.	VII.	
34	38	48	TOTAL NUMBER OF READINGS.
5	1	2	Pause after each syllable.
12	20	15	Pause after every second syllable.
0	1	0	Pause after every third syllable.
?	?	?	Absent or irregular.

There are frequent lapses into a primary rhythm in the trochaic reading of the first grade. With one exception, this primary grouping retained the temporal, intensive or qualitative subordination characteristic of a trochaic grouping.

There are a large number of irregular readings among the American children of the first grade; the boys, particularly, were very unrhythmical.

Results from the Trochaic Readings by Method II. Figures for time and pitch represent the mean values for each series.

TABLE XII.—*C. D.*

	TIME.				Intensity.	Pitch.
	Syllable. (a)	Syllable. (b)	Pause. (a)	Pause. (b)		
(1)	.789 sec.	.361 sec.	.093 sec.	.435 sec.	a > b (3); a=b (8)	a=b
(2)	.743 "	.313 "	.102 "	.597 "	a=b (12)	a=b
(3)	.985 "	.312 "	.12 "	.402 "	a > b (4); a=b (6)*	a higher than b.
(4)	.87 "	.311 "	.102 "	.545 "	a=b (11)*	a higher than b.
(5)	.767 "	.398 "	.062 "	.358 "	a=b (14)	a 318.75 vib. b 318.75 vib.
(6)	.802 "	.504 "	.065 "	.311 "	a > b (6); a=b (1)	a 300.93 " b 288.43 "

*The microphone responded poorly.

TABLE XIII.—*H.*

TIME.				Intensity.	Pitch.
Syllable. (a)	(b)	Pause. (a)	(b)		
(1) .419 sec.	.25 sec.	.183 sec.	.416 sec.	a> b (7); a=b (2)	a higher than b
(2) .46 "	.365 "	.142 "	.23 "	a> b (15); a=b (1)	a " " b
(3) .444 "	.448 "	.14 "	.206 "	a> b (13)*	a " " b
(4) .52 "	.438 "	.131 "	.24 "	a> b (15)*	a " " b
(5) .409 "	.414 "	.115 "	.131 "	a> b (14)	a 306 .25 vib. b 257 .69 vib.

**a* twice as intensive as *b*.

Pitch intervals vary between a second and a fourth.

TABLE XIV.—*R. A.*

TIME.				Intensity.	Pitch.
Syllable. (a)	(b)	Pause. (a)	(b)		
(1) .58 sec.	.445 sec.	.43 sec.	.595 sec.	a=b(10)	a=b
(2) .57 "	.457 "	.42 "	.513 "	a> b (7); a=b(3)	a=b
(3) .504 "	.195 "	.19 "	.984 "	a=b(12)*	a=b
(4) .488 "	.397 "	.193 "	.638 "	a=b(10)*	a=b
(5) .628 "	.575 "	.413 "	.44 "	a> b (3);a=b (7)	a higher than b
(6) .637 "	.56 "	.362 "	.437 "	a> b (3);a=b (5)	a higher than b
(7) .647 "	.347 "	.387 "	.493 "	a=b (10)	a higher than b

*The microphone responded poorly.

Difference in pitch, when present, never exceeded the major second.

Some of the series were taken under favorable conditions, the microphone responding as readily as could be desired; where particular difficulties were experienced, they have been noted.

There was a secondary grouping in the reading of *H.* and *C. D.*, corresponding to the breathing rhythm, which could not be shown in the tabulated results; each of the larger groups contained six to ten smaller groups (or in metrical language 6 to 10 feet). The larger groups were separated by longer pauses of .3 to .7 sec. in duration.

The difference between the lengths of the intervening and the succeeding pause increased from the first grade up; *R. A.* (first grade) gave, with the exception of two series, very slight time-differences in her readings; with *H.*, the differences in duration of the pauses, although greater than with *R. A.*, were not marked; while with *C. D.* they were very marked. The same thing is true of the duration of the syllables, but in a less noticeable degree.

The results for intensity are not entirely satisfactory, for, as

C. D. complained at the time of the third series, in order to give the weak syllable intensity enough to insure a response from the microphone, it was necessary to speak so loudly that the loudest syllable could hardly be made more intense. The correlation between greater frequency and completeness of intensive subordination and increase in age is not borne out in this experiment. The lack of delicacy in the responses of the microphone was, no doubt, a partial cause, although not a sufficient one. The natural reading of *C. D.* never showed great intensive variations.

In the two cases where *R. A.*'s reading showed a noticeable temporal subordination, there was neither an intensive nor a qualitative differentiation present: this was a case of supplementing similar to Meumann's *Stellvertretung*. *R. A.*'s grouping is not of any particular type; it is partly temporal, partly intensive, and for the last series slightly qualitative.

H. tends to a markedly intensive-qualitative rhythm; temporal differences are very slight. In series (3) he approached a spondaic time order. Pitch differences are always present, and greater than for *C. D.* or *R. A.* *C. D.*'s reading is of a temporal type, with few or slight differences in intensity or pitch, but with striking differences in temporal arrangement.

H.'s reading was always more natural, less strained, than that of *C. D.* *C. D.* was, as has been stated, a very painstaking, conscientious child, and labored to give what he thought was desired; while *H.* read as he pleased. It is therefore probable that in the grouping given by *H.* we have a nearer approach to the natural spontaneous rhythm of speech.

The figures for pitch are, like those for time, averages of long series; they do not therefore represent the number of vibrations which were actually given, but show all that they were expected to represent,—the relative intervals between the two syllables. In the readings given by *R. A.*, and in the greater number of those given by *H.* and *C. D.*, it was impossible to read the number of vibrations as shown on the record. By a change in the recording apparatus and an increase of the rate of revolution of the drum, we were enabled, however, to obtain a few records which showed approximately the number of vibrations; it was necessary, even in this case, to use a magnifying glass for reading the records.

It is to be noted that the time-relations could not be expressed by simple numbers.

Total for Five Series of Iambic Readings.

In this case the children were requested to emphasize the second and every alternate syllable.

TABLE XV (*a*).

Pitch Variations. (*Present.*)

I.	IV.	VII.	
6 p. 2 m. 10 i. 2 ir.	14 p. 0 m. 1 i. 1 ir.	10 p. 9 m. 3 i. 1 ir.	G. B.
9 p. 1 m. 4 i. 0 ir.	13 p. 4 m. 1 i. 0 ir.	20 p. 1 m. 3 i. 1 ir.	G. G.
7 p. 2 m. 0 i. 2 ir.	13 p. 0 m. 6 i. 0 ir.	17 p. 0 m. 0 i. 0 ir.	A. B.
4 p. 0 m. 0 i. 1 ir.	9 p. 3 m. 2 i. 0 ir.	14 p. 0 m. 0 i. 2 ir.	A. G.
26 p. 5 m. 14 i. 5 ir.	49 p. 7 m. 10 i. 1 ir.	47 p. 10 m. 6 i. 4 ir.	Total.

TABLE XV (*b*).

Pitch Variations. Absent.

I.	IV.	VII.	
0	3	0	G. B.
2	0	0	G. G.
13	3	2	A. B.
16	7	5	A. G.
31	13	7	Total.

(1) The parallelism between increasing differentiation of the rhythm and increasing age is still noticeable, although there is scarcely any difference between the fourth and the seventh grades in this respect. (2) A qualitatively determined rhythm still appears to be characteristic of the German rather than of the American reading. (3) The cases of inversion are much more frequent than with the trochee; this is particularly true of the Germans, who in such cases reverted to a pure trochaic form. (4) Comparing the trochaic and iambic groupings as to pitch relations, we note that there is exactly the same number of absences in the iambic as in the trochaic readings of both the first and fourth grades; but with the seventh grade, pitch variations are absent but seven times, while with the trochee they are wanting in eleven readings. (5) There are fewer instances of intervals of a fourth in the iambus than in the trochee; the intervals often gradually diminished as the reading proceeded. This fluctuation in pitch was a characteristic feature of the iambic grouping.

(1) Regular intensive variations are less frequent than are qualitative. (2) They occur more rarely than in the trochaic grouping. The greater variety of intensive variations in the iambus is doubtless due to the same cause as the smaller pitch intervals. The result is a weakening and fading-out of the

TABLE XVI (*a*).

Intensity Variations. (*Present.*)

I.	IV.	VII.	
6 p. 4 m. 1 i. 0 ir.	7 p. 5 m. 0 i. 0 ir.	16 p. 2 m. 0 i. 0 ir.	G. B.
6 p. 5 m. 0 i. 1 ir.	16 p. 4 m. 0 i. 0 ir.	13 p. 2 m. 0 i. 0 ir.	G. G.
2 p. 0 m. 0 i. 0 ir.	9 p. 2 m. 1 i. 1 ir.	9 p. 2 m. 2 i. 0 ir.	A. B.
7 p. 2 m. 0 i. 4 ir.	7 p. 2 m. 1 i. 2 ir.	12 p. 3 m. 0 i. 0 ir.	A. G.
21 p. 11 m. 1 i. 5 ir.	39 p. 13 m. 2 i. 3 ir.	40 p. 9 m. 2 i. 0 ir.	Total.

TABLE XVI (*b*).

Intensity Variations. (*Absent.*)

I.	IV.	VII.	
3	7	5	G. B.
3	3	8	G. G.
20	7	6	A. B.
11	7	5	A. G.
37	24	24	Total.

distinctive marks. *Cf.* later discussion. (3) Correlation of increasing intensive differentiation with increasing age is still to be noted, although not marked.

TABLE XVII (*a*).

Time Variations. (*Present.*)

I.	IV.	VII.	
2 p. 0 m. 1 i. 0 ir.	9 p. 3 m. 0 i. 0 ir.	13 p. 1 m. 0 i. 0 ir.	G. B.
2 p. 1 m. 2 i. 0 ir.	11 p. 4 m. 1 i. 0 ir.	11 p. 4 m. 4 i. 0 ir.	G. G.
3 p. 0 m. 2 i. 0 ir.	10 p. 1 m. 2 i. 0 ir.	10 p. 2 m. 1 i. 0 ir.	A. B.
9 p. 0 m. 2 i. 0 ir.	10 p. 1 m. 2 i. 0 ir.	10 p. 2 m. 1 i. 0 ir.	A. G.
16 p. 1 m. 7 i. 0 ir.	40 p. 9 m. 5 i. 0 ir.	44 p. 9 m. 7 i. 0 ir.	Total.

TABLE XVII (*b*).

Time Variations. (*Absent.*)

I.	IV.	VII.	
15	7	9	G. B.
11	7	6	G. G.
17	8	5	A. B.
9	4	4	A. G.
52	26	24	Total.

(1) Cases of inversion in the temporal relations are far more numerous in the iambus than in the trochee; although subordinations in temporal arrangement are about as frequent. (2) The irregularities found in the intensive, and still more often in the qualitative arrangement disappear here entirely. (3) The parallelism found in all the other instances is still to be noted.

TABLE XVIII.

P. and I. present together.			T. and I. present together.			P. and T. present together.			
I.	IV.	VII.	I.	IV.	VII.	I.	IV.	VII.	
13	5	5	1	3	1	0	2	0	G. B.
7	5	3	1	1	3	0	0	0	G. G.
0	2	3	2	2	3	1	2	3	A. B.
2	3	2	2	4	3	4	1	0	A. G.
22	15	13	6	9	10	5	5	3	Total.

P., T. and I. present.			P., T. and I. absent.		
I.	IV.	VII.	I.	IV.	VII.
1	5	12	18	13	11
4	15	13	11	5	12
0	9	7	22	13	11
3	11	11	19	11	8
8	40	43	70	42	42

A grouping marked only by variations in *P.* and *I.* is still favored by the German children, especially by the first grade boys. *P.* and *T.* variations seldom occur alone; this was noted in the trochaic grouping. *T.* and *I.* are still favored by the Americans rather than by the Germans. *P.*, *T.* and *I.* subordinations within the same group are less frequent than in the trochee; this is especially true of the first grade. An exception to this rule is furnished by the reading of the German girls in the fourth grade; it can be partly accounted for by the fact that the full number of readings was given by a girl of a distinctly iambic-anapæstic type. In general we note here the same tendency to a looser grouping, *i. e.*, one possessing fewer distinctive marks, that was before noted.

Pause.—For the reason before mentioned, the results from the German children are not complete.

A pause often occurs after the first syllable, together with differences in pitch and in intensity. In the primary grouping, each syllable was frequently pronounced with a strong expira-

TABLE XIX (*a*).

Position of Pause. Americans.

(Results for boys and girls given together.)

I.	IV.	VII.	
44	44	37	TOTAL NUMBER OF READINGS.
8	4	1	Pause after each syllable.
25	33*	37	Pause after every second syllable.
11	4	0	Pause absent or irregular.

TABLE XIX (*b*).

Position of Pause. Germans.

(Results of boys and girls given together.)

I.	IV.	VII.	
34	38	48	TOTAL NUMBER OF READINGS.
5	1	0	After every syllable.
6	9	23	After every second syllable.
?	?	?	Absent or irregular.

*One child gave a double two-grouping by lengthening the pause after the fourth in relation to that after the second syllable.

tory movement. There are more instances of irregularities than in the trochaic rhythm. A reversion to forms 2 and 3 of the involuntary series, *i. e.*, a grouping effectuated by pause alone, occurred eleven times among the American boys of the first grade and six times among the girls of the same grade.

With the first grade, the iambic grouping is loose, *i. e.*, it lacks the unitary character of the trochaic; it is frequently turned into the trochaic form through inversion in time, pitch or intensity, or in all three.

Results from the Iambic Readings by Method II. Figures for time and pitch represent the mean values of each series.

TABLE XX.—*C. D.*

TIME.				Intensity.	Pitch.
Syllable. (a)	Syllable. (b)	Pause. (a)	Pause. (b)		
(1) .613 sec.	.685 sec.	.13 sec.	.3 sec.	b> a (14); b=a (1)	?
(2) .607 "	.625 "	.121 "	.344 "	b> a (9); b=a (4)	b higher than a
(3) .733 "	.766 "	.123 "	.251 "	b> a (10); b=a (2)	b " " a
(4) .716 "	.688 "	.123 "	.345 "	b> a (11); b=a (1)	b " " a
(5) .803 "	.792* "	.086 "	.166 "	b> a (1); b <a (14)*	a 313.33 vib. b 362.22 "
(6) .71 "	.767 "	.076 "	.196 "	b> a (1); b=a (4); b <a (6)	a 282.35 " b 297.97 "

*Time and intensity trochaic, voice-fall iambic.

TABLE XXI.—*H.*

TIME.				Intensity.	Pitch.
Syllable. (a)	(b)	Pause. (a)	(b)		
(1) .495 sec.	.439 sec.	.112 sec.	.225 sec.	Record not clear.	b higher than a
(2) .389 "	.385 "	.116 "	.298 "	b> a (8); b=a (3)	b " " a
(3) .415 "	.451 "	.147 "	.195 "	b> a (12); b=a (1); b <a (3)	b " " a
(4) .379 "	.27* "	.223 "	.496 "	b> a (2); b=a (2); b <a (10)	b " " a
(5) .398 "	.34 "	.148 "	.203 "	b> a (14); b=a (4); b <a (1)	b " " a
(6) .483 "	.374 "	.151 "	.293 "	b> a (12); b=a (3); b <a (1)	b " " a
(7) .364 "	.411 "	.116 "	.146 "	b> a (15); b=a (1)	a 298.9 vib. b 371.25 vib.

*He begins after each inspiration with a trochaic grouping, which gradually becomes iambic; fluctuation between trochaic and iambic grouping is characteristic of the whole series.

TABLE XXII.—*R. A.*

TIME.				Intensity.	Pitch.
Syllable. (a)	(b)	Pause. (a)	(b)		
(1) .555 sec.	.362 sec.	.437 sec.	.59 sec.	b=a (12)	No variations
(2) .486 "	.486 "	.4 "	.432 "	b> a (6); b=a (4); b <a (1)	" "
(3) .417 "	.293 "	.323 "	.866 "	b=a (10)	" "
(4) .398 "	.38 "	.267 "	.745 "	b=a (7); b <a (3)	" "
(5) .414 "	.442 "	.36 "	.431 "	b=a (12)	" "
(6) .473 "	.437 "	.437 "	.466 "	b=a (12)	" "
(7) .582 "	.537 "	.411 "	.35 "	b=a (8); b <a (3)	a higher than b
(8) .51 "	.568 "	.446 "	.473 "	b> a (2); b=a (9); b <a (1)	a higher than b

R. A., as a rule, gave the iambus the temporal arrangement of the trochee; exceptions to this rule were: in series 2, (a) and (b) were of exactly the same duration; and series (5) and (8) showed a slight lengthening of the second syllable in comparison with the first. When intensive subordinations occurred, though these were less frequent than temporal, (a) was more intense than (b), except during part of series (2) and (8), where (b) was slightly more intense than (a). Voice-fall, if noticeable at all, was always trochaic. A tendency to primary grouping, through making the pause following (a) nearly as long as that following (b), was characteristic of *R. A.*'s reading as a whole; this is especially true of series (5), (6), (7) and (8). A peculiarity of series (7) is the presence of a longer pause after (a) than after (b).

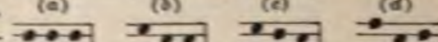
With *H.* there is evidence of a conflict between the tendency to give the more natural trochaic grouping and his desire to read as asked. The temporal arrangement is trochaic in series (1), (2), (4), (5) and (6). Intensive subordinations are far more frequent than with *R. A.;* part of every series has an

iambic arrangement of intensity, although no one series has this arrangement only. The voice-fall throughout is that found to be typical of the iambic grouping; the interval is slightly greater than in the trochee. Here, as in the results obtained from the trochaic reading, *H.*'s reading was determined by intensive and qualitative rather than by temporal subordination. His arrangement of pauses [(b) having a greater duration than (a)] results in a more unitary grouping than the arrangement given by *R. A.*

With the exception of series (4) and (5), *C. D.* preserved the characteristic temporal arrangement of the iambus, although the difference between the duration of (a) and (b) was not so great as in the trochaic reading; there, (b) had a duration varying from one-half to one-third that of (a), while here the difference never exceeded a few hundredths of a second. Neither is the relative difference in the duration of the pauses so great as with the trochee; however, the subordination of the intervening pause to the succeeding is greater than in *H.*'s reading, and markedly greater than in *R. A.*'s. While the syllables (a) and (b) are often given the same intensity, the only cases of inversion in intensive arrangement are found in series (5) and (6). The voice-fall throughout was the characteristic iambic. *C. D.*'s reading as a whole was characterized by fewer inversions than *H.*'s and greater unity in the grouping than *R. A.*'s. All three experienced greater difficulty in rendering the iambic; this is in harmony with the result obtained by Method I.

Total for Five Series of Dactylic Readings.

The problem was modified by requiring the emphasis on the first syllable and every third following. Four arrangements of the syllables, as to pitch, (a) (b) (c) (d) were noted. The arrange-



ment is not intended to denote absolute relations, but merely to show the direction of variation.

TABLE XXIII.

German.				American.			
I.	IV.	VII.		I.	IV.	VII.	
4	0	0	Order (a)	20	5	4	Order (a)
13	18	25	" (b)	7	30	26	" (b)
9	2	2	" (c)	0	3	4	" (c)
3	10	4	" (d)	0	0	2	" (d)

This tabulation does not account either for the irregular readings or for the cases of inversion, which would have nearly an obverse arrangement. In the reading given by the German

children, it is to be observed that arrangement (a) occurs only in the first grade; (c) occurs more frequently in the first grade; (b), the commonest form, is found in all the grades; (d) occurs more frequently in the higher grades. If we compare the readings of the American with those of the German children, the greater frequency of arrangement (a) in the reading of the former is noticeable; (c) occurs more frequently in the readings of the fourth and seventh American grades than with the Germans; while (b) seems in the great majority of cases to be the closest grouping obtained by the Americans, (d) occurring only twice, and then in the seventh grade. This shows, even more strikingly than the results obtained in the trochaic and iambic readings, the greater tendency of the German children toward the introduction of a qualitative determinant into the simplest grouping.

It might be asked whether the ascending order of rhythmical grouping, as to unity and complexity of the rhythm, is in the order (a), (b), (c) and (d). Does (d) give a more unitary impression than (b)? For us, (d) is a much more satisfactory arrangement. *Cf.* the discussion of pitch below.

TABLE XXIV (*a*).

Pitch Variations. (*Present.*)

I.	IV.	VII.	
13 p. 1 m. 4 i. 0 ir.	14 p. 3 m. 0 i. 1 ir.	14 p. 7 m. 0 i. 1 ir.	G. B.
9 p. 1 m. 0 i. 3 ir.	15 p. 7 m. 0 i. 0 ir.	21 p. 2 m. 0 i. 1 ir.	G. G.
0 p. 1 m. 0 i. 1 ir.	13 p. 2 m. 2 i. 0 ir.	12 p. 2 m. 1 i. 0 ir.	A. B.
6 p. 1 m. 1 i. 0 ir.	18 p. 1 m. 0 i. 0 ir.	12 p. 3 m. 2 i. 0 ir.	A. G.
28 p. 4 m. 5 i. 4 ir.	60 p. 13 m. 2 i. 1 ir.	59 p. 14 m. 3 i. 2 ir.	Total.

TABLE XXIV (*b*).

Pitch Variations. (*Absent.*)

I.	IV.	VII.	
1	1	0	G. B.
3	0	1	G. G.
18	5	3	A. B.
16	3	2	A. G.
38	9	6	Total.

The American boys of the first grade, and three of the girls, failed in every attempt to produce the dactyl and the anapæst, falling into an unaccented two-grouping, a weakly accented

TABLE XXVI (*b*).

Time Variations. (*Absent.*)

I.	IV.	VII.	
9	3	4	G. B.
13	4	2	G. G.
16	3	3	A. B.
13	2	1	A. G.
51	12	10	Total.

(1) There are fewer irregularities in the temporal than in the intensive and qualitative arrangement. (2) The parallelism between increased age and increased frequency of differentiating marks, found in all the other Tables, does not fail here.

There were a number of temporal arrangements observed; at times the first seemed as long as the second and third together; then the first appeared only a trifle longer than the second, and the second longer than the third; and then again the first had the greatest duration, the third came next in order of duration, while the second had the least. These results were objectively substantiated by the results of Method II. *Cf.*, for further discussion, temporal factor in rhythm.

TABLE XXVII.

P. and I. present together.			T. and I. present together.			P. and T. present together.			
I.	IV.	VII.	I.	IV.	VII.	I.	IV.	VII.	
4	1	3	0	1	0	1	0	3	G. B.
6	2	1	0	3	1	2	2	0	G. G.
0	1	1	1	2	1	0	0	0	A. B.
2	0	0	3	1	1	0	0	1	A. G
12	4	5	4	7	3	3	2	4	Total.

P. T. and I. present.			P. T. and I. absent.		
I.	IV.	VII.	I.	IV.	VII.
8	14	14	11	4	9
0	16	16	15	4	9
1	11	10	21	11	8
5	16	15	17	6	4
14	57	55	64	25	30

It is interesting to note how much more complete the dactylic

grouping is than the trochaic or the iambic. P., T. and I variations occur together:

	I.	IV.	VII Grades.
In the trochaic readings,	13	41	51 times.
In the iambic readings,	8	40	43 times.
But in the dactylic readings,	14	57	55 times.

The greater number of possible arrangements of these three factors gives a variety and richness of content impossible in the two-groupings.

Table XXVIII (*a*).

Position of Pause. Americans.

(Results for boys and girls given together.)

I.	IV.	VII.	
44	44	37	Total Number of Readings.
8	1	0	After every syllable.
6	2	0	After every second syllable.
12	20	20	After every third.
6	18	16	After first and third.
12	3	1	Absent or irregular.

Table XXVIII (*b*).

Position of Pause. Germans.

(Results for boys and girls given together.)

I.	IV.	VII.	
44	44	37	Total Number of Readings.
8	1	1	After every syllable.
1	1	0	After every second syllable.
5	11	11	After every third.
8	15	24	After every first and third.
?	?	?	Absent or irregular.

(1) There was frequently a minor pause after the first with a longer pause after the third; this was especially true of the readings of the children of the upper grades. (2) We still find instances, notably in the first grade, in which a pause occurred after each syllable; generally then the primary rhythm was produced, though there were instances in which accented syllables were so separated. The appearance of the two-grouping also marked the failure of the younger children to bring the three syllables into an unity.

otherwise the duration of the pauses followed the inverse order of the syllables. Variations in intensity were nearly always present. The arrangements were the same as those found in *H.*'s reading; ——'' —— ——' was noted seven times, ——'' ——' —— eight times, and ——'' —— —— 39 times. There was one case of inversion in pitch (*cf.* last series); otherwise the only two forms noted were those found to be characteristic of the older children in the free readings.

Total for Five Series of Anapæstic Readings.

In a general way the anapæstic grouping was the obverse of the dactylic, in its temporal, intensive and qualitative arrangements.

TABLE XXXII.

German.				American.			
I.	IV.	VII.		I.	IV.	VII.	
0	0	0	Order (a)	0	0	0	Order (a)
12	19	32	" (b)	8	27	26	" (b)
2	2	6	" (c)	0	3	1	" (c)
3	19	9	" (d)	0	1	1	" (d)

Arrangement (d) occurred more frequently in the reading of the German children; this is in harmony with all the results so far obtained. Arrangement (c) appeared very seldom even among the younger children. less frequently even than in the dactylic grouping. Arrangement (b) is most frequent with all the grades.

TABLE XXXIII (*a*).
Pitch Variations. (*Present.*)

I.	IV.	VII.	
5 p. 3 m. 7 i. 1 ir.	12 p. 2 m. 1 i. 0 ir.	11 p. 9 m. 0 i. 1 ir.	G. B.
7 p. 0 m. 3 i. 2 ir.	15 p. 7 m. 1 i. 0 ir.	12 p. 8 m. 2 i. 0 ir.	G. G.
1 p. 0 m. 3 i. 0 ir.	11 p. 0 m. 4 i. 0 ir.	12 p. 1 m. 3 i. 0 ir.	A. B.
3 p. 1 m. 3 i. 1 ir.	14 p. 2 m. 2 i. 1 ir.	13 p. 1 m. 3 i. 0 ir.	A. G.
16 p. 4 m. 16 i. 4 ir.	52 p. 11 m. 8 i. 1 ir.	48 p. 18 m. 8 i. 1 ir.	Total.

TABLE XXXIII (*b*).
Pitch Variations. (*Absent.*)

I.	IV.	VII.	
3	4	1	G. B.
4	0	2	G. G.
17	6	2	A. B.
13	3	3	A. G.
37	13	8	Total.

(1) There were a greater number of large intervals recorded in the German than in the American readings. (2) There were more cases of inversion than in the rendering of dactyls. (3) Pitch entered less frequently as a determinant of grouping than in the dactyl.

TABLE XXXIV (*a*).

Intensity Variations. (*Present.*)

I.	IV.	VII.	
6 p. 7 m. 0 i. 0 ir.	9 p. 4 m. 0 i. 0 ir.	11 p. 9 m. 0 i. 1 ir.	G. B.
5 p. 4 m. 1 i. 1 ir.	13 p. 2 m. 0 i. 0 ir.	4 p. 6 m. 0 i. 0 ir.	G. G.
0 p. 0 m. 1 i. 2 ir.	7 p. 2 m. 5 i. 0 ir.	14 p. 1 m. 0 i. 0 ir.	A. B.
9 p. 3 m. 0 i. 1 ir.	9 p. 2 m. 2 i. 3 ir.	14 p. 0 m. 1 i. 0 ir.	A. G.
20 p. 14 m. 2 i. 5 ir.	38 p. 10 m. 7 i. 3 ir.	43 p. 16 m. 1 i. 1 ir.	Total.

TABLE XXXIV (*b*).

Intensity Variations. (*Absent.*)

I.	IV.	VII.	
5	6	1	G. B.
5	7	15	G. G.
17	5	3	A. B.
13	6	4	A. G.
40	24	23	Total.

The number of inversions in intensity was less than in pitch; but intensive variations were frequently absent.

TABLE XXXV (*a*).

Time Variations. (*Present.*)

I.	IV.	VII.	
1 p. 1 m. 0 i. 0 ir.	8 p. 2 m. 0 i. 1 ir.	9 p. 3 m. 0 i. 0 ir.	G. B.
2 p. 0 m. 1 i. 0 ir.	13 p. 3 m. 1 i. 0 ir.	12 p. 8 m. 2 i. 1 ir.	G. G.
1 p. 0 m. 3 i. 0 ir.	9 p. 3 m. 3 i. 0 ir.	14 p. 1 m. 0 i. 0 ir.	A. B.
2 p. 3 m. 0 i. 1 ir.	13 p. 3 m. 1 i. 3 ir.	12 p. 0 m. 2 i. 0 ir.	A. G.
6 p. 4 m. 4 i. 1 ir.	43 p. 11 m. 5 i. 4 ir.	47 p. 12 m. 4 i. 1 ir.	Total.

	PITCH.	
	Syllab	
(a)	(b)	
(1) .33 sec.	.283	
(2) .366 "	.354	
(3) .535 "	.516	
(4) .566 "	.58	
(5) .622 "	.65	ib.; (b) 300 vib ; (c) 362.6 vib.

	PITCH.	
	Syllabl	
(a)	(b)	
(1) .348 sec.	.325	
(2) .363 "	.332	
(3) .36 "	.364	
(4) .404 "	.377	
(5) .45 "	.343	
(6) .343 "	.321	318.3 vib. ; (c) 357.7 vib.

	PITCH.	
	Syllabl	
(a)	(b)	
(1) .307 sec.	.288	:e.
(2) .283 "	.253	
(3) .368 "	.346	
(4) .454 "	.446	
(5) 489 "	.491	
(6) .55 "	.57	
(7) .616 "	.633	

[illegible]

observed gave the curious arrangement . *Cf.* section on Pitch.

The frequent inversion in the reading of all three, the tendency of *R. A.* to pass over to an entirely unmodified or primary rhythm, and the conflicts between (or absence of) differentiating marks in the readings of *H.* and *C. D.*, point to an inherent difficulty in the anapæstic arrangement.

§ 3. SUMMARY.

Two main problems now present themselves. (1) We must enquire into the arrangement of the different rhythmical forms in order of psychological complexity, using the facts brought out in the experiment as a basis for classification and finding, if we can, an adequate psychological explanation for this order. (2) We must collate the data with reference to the objective factors which determine the grouping, and consider their meaning for consciousness.

1. Does the order of increasing difficulty run parallel with that of increasing rhythmical perfection,—rhythmical perfection connoting unitariness of impression for the hearing subject? The predominance of the primary grouping in the free reading of the younger children would indicate a separateness of each syllable or impression in the early consciousness. There are several forms in which a tendency towards a primary rhythm can be discovered in the restrained readings of the same children. It appears in the form of equal pauses, regularly recurring after each syllable,—although these syllables differ regularly among themselves, as to duration, intensity, or pitch; again, in a rhythm of the same character as the former, but lacking the *regular* recurrence of differences,—one syllable being raised above the other at *irregular* intervals; and, finally, in the primary rhythm in which the syllables do not differ perceptibly as to duration, intensity or pitch. These appear to be retrogressive stages which the complex forms undergo, resulting in a gradual loss of their unitary character through the fading out of their distinctive marks; till at last the primary form, the simple, disconnected, although regular succession of one sensation after another is reached. The result seems to be due to a gradual blunting of the sensible discrimination, a blunting which at times is objectively conditioned by the slow rate of succession. A comparison of two syllables, relatively easy when the syllables succeeded each other at such a rate that both fell within the limits of immediate time perception, would be more difficult at a slower rate of succession. Why, then, does this slow rate of succession appear? It follows both from the inability to attend to more than one syllable at a time, *i. e.*, from an extreme narrowness of the range of attention;

and from the slowness with which the attention of the young child functionates, *i. e.*, the longer time necessary to bring any impression into the focus of attention. This retardation doubtless arises through lack of inhibitory control. These facts are shown more clearly in the Tables for the time of a whole series. [Tables XLII (*a*) and (*b*).]

Under experimental conditions, the strained attention of adults has been found to cover forty impressions succeeding one another at a rate of from .2 to .3 sec.; but these results, representing as they do the maximal value for trained adults, cannot be approximated in the case of children. Moreover, in the figures given by Wundt[1] the range does not exceed five *units* (each unit containing eight beats) or eight units (each unit containing two beats). An *unit* made up of several impressions is nearly as readily perceived as the simple uncompounded unit; this is of course dependent upon the completeness of unity. Bolton's Subject 9 found that he could not hold more than eight or nine clicks together. Apparently, the range of attention for adults does not exceed eight separate units; with the young child one or at best two *separate* impressions or units seem to be the limit.

The errors arising from the reading of the different restrained forms by Method I, made as they were by so many individuals, have considerable weight in settling the question of the psychological priority of the two over the three grouping. For that reason they have been brought together in tabular form. They are errors in the sense that they are deviations from the normal manner of reading and are due to inversions of one or all of the objective determinants of rhythm, or to general irregularities.

TABLE XLI.

First Grade.

Germans. 35 Readings.		Americans. 46 Readings.
Trochee,	1 failure.	17 failures.
Iambus,	12 "	22 "
Dactyl,	4 "	24 "
Anapæst,	15 "	33 "

Fourth Grade.

Germans. 41 Readings.		Americans. 43 Readings.
Trochee,	4 failures.	0 failures.
Iambus,	4 "	15 "
Dactyl,	1 "	4 "
Anapæst,	3 "	12 "

[1] Outlines, Eng. Translation, pp. 214 ff.

Seventh Grade.

	Germans. 49 Readings.	Americans. 39 Readings.
Trochee,	1 failure.	3 failures.
Iambus,	7 "	6 "
Dactyl,	2 "	5 "
Anapæst,	2 "	7 "

The American boys of the first grade and three of the girls failed in every attempt to produce the dactyl and anapæst. The preference for (and priority of) the two over the three group has been brought out in nearly all of the investigations that have touched upon the question. Miss Smith[1] reports an apparent exception, in which the subject always chose a three-grouping; but it is to be remembered that not only was the subject an adult, who had doubtless made some strong association with the three-grouping, but the purpose of the experiment was the investigation of the effects of the different rhythms upon the memorizing of nonsense syllables. It can be readily understood that the three-grouping, because it broke the total number of impressions into fewer unities, might be more advantageous for memorizing than a two-grouping; this instance cannot therefore be regarded as an exception to the rule that the two-group is psychologically simpler than the three-group. Kuelpe[2] accounts for the greater ease with which even numbers of impressions are compared than odd by the natural tendency to a two-grouping, although he does not explain this tendency. Bolton's[3] subjects had the prevailing tendency to group by twos or fours (which latter is merely a doubling of the two-grouping). In our later experiments with adults on the influence of pitch variations, whenever there was no objective difference between the sounds and subjective grouping took place, the grouping was always by twos or multiples of two. The three-grouping, which Bolton was able to suggest to a few subjects did not once occur with ours, although series of equal sounds were alternated in every experiment with series that were objectively grouped in threes. This suggestion should have been strong enough to have brought about a three-grouping, if mere suggestion was sufficient. Lanier[4] says: "I think no subject in the history of æsthetics is so curious as the overpowering passion of the English ear for a three rhythm [the two-group] as opposed to the four rhythm" [the three-group]. From our father Caedmon through all the wonderful list down

[1] *Op. cit.*, p. 217.
[2] Grundriss der Psychologie, 1893, p. 409.
[3] *Op. cit.*, p. 216.
[4] *Op. cit.*, p. 41.

to the present day, every long poem and nearly every important short poem in the English language has been written in some form of the three rhythm" [the two-group].[1]

There can be no question but that the two-group is psychologically prior to the three-group. Why should this be the case? Numerous answers are given. Some explain that the two-group falls within the bounds of the natural period of attention. But the three-group has a shorter duration than the two, and would therefore more certainly fall within the required bounds. An explanation in harmony with Buecher's theory must seek to derive the fact of a psychological simplicity of the two-rhythm from its more frequent use in the work of primitive man. Others explain this preference for the two-rhythm as due to its accordance with the bodily rhythms, the expiration and inspiration of respiration, the diastole and systole of the heart, and the swing of the right and left leg in walking.

There is no one principle which satisfactorily explains the preference for the two-rhythm; but there are both psychological and physiological grounds for this preference. That we can think (and use in practical life) a large variety of combinations; while we are, as a matter of fact, restricted to some form of two or three grouping, or their multiples, in rhythmical combinations; is due, we may suppose, to the relativity of our sensible discrimination for intensities. At most we can directly compare but three, and two intensities are compared with greater ease and exactness. This, then, gives us one reason for the preference of the two-rhythm. Moreover, a two-grouping is reinforced by all of the bodily rhythms which fall into unison with any two-rhythm. Thus what is psychologically most simple is also most in harmony with the physiological mechanism.

Is one form of the two-rhythm psychologically more simple than another? Does the accent fall on the last syllable as readily as on the first? The experimental results would indicate, especially in the case of the younger children, that the accent falls most naturally on the first syllable: *cf.* the great number of cases in which, when the iambic reading was required, the trochaic was given. Other results, beside the proportion of failures in the trochaic and iambic readings, point to the earlier perfection of the trochaic; temporal subordination was not as marked in the case of the iambus as in that of the trochee. There were also a greater number of temporal inversions. The first grade, in their attempt to render the iambus,

[1] Lanier used a peculiar notation based upon the musical: the trochee and iambus have according to this notation three time units, the long (equal to two short) *plus* a short.

reverted very frequently to a grouping characterized only by the pause (either in the form of the primary rhythm or of the spondee). The pitch intervals for the iambus were smaller than for the trochee, and intensity differentiations were also less frequent. Both often decreased in the course of the reading; this no doubt was the result of the gradual withdrawal of the attention from its unnatural position on the second syllable, and in the cases of complete inversion to focusing of the attention on the first syllable of the group. Wundt[1] regards the iambus and trochee as equally simple psychologically; but in the face of experimental facts to the contrary his view can hardly be maintained. Bolton[2] found that the first sound in the two grouping was accented. The second could be accented by suggestion, but no subjects would agree that it was the natural accent. The experiments show, however, that the great difference between the ease and correctness with which the trochee and iambus are rendered decreases with increasing years, until a few children of the fourth and seventh grades appeared to prefer this grouping. Meumann,[3] although he agrees with Wundt as to the simplicity of the iambus, gives us a partial explanation for the trochaic being the more natural grouping. "Central adaptation is more rapid when the first introduction of a rhythmical motive is powerful." Thus the strengthening of the first part of the foot gives any grouping a greater efficacy for reproduction. Ettlinger,[4] who regards accent as due to the influence of a backward moving force in its inhibition of the forward, finds the trochaic the most natural grouping because the influence of the inhibitory force is strongest immediately after the pause. When Ettlinger's theory is put in terms of attention, the explanation of the natural preference of the trochee is that the first sound following the pause receives, by virtue of contrast with silence, greater attention than the second sound. Thus, even when not objectively accented, it receives a subjective stress as a result of the clearness with which it is focused by the attention.

Riemann[5] derived the three-group from what he considered the most perfect form of the two-group,—one in which the long was equal to two short. These three equal time units are the basis for the three-grouping. But this is not necessarily the most perfect form of the two-group. On the contrary, the proportion of two to one does not seem to be natural (*cf.* Tables).

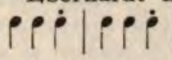
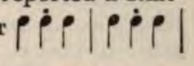
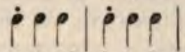
[1] Grundzüge, II, p. 86.
[2] *Op. cit.*, p. 222.
[3] *Op. cit.*, p. 299.
[4] Zur Grundlegung einer Æsthetik des Rhythmus, Zeitschrift, XXII, p. 187.
[5] Musik-Lexicon, Article *Metrik* (quoted by Meumann).

The time relations as shown by the experiment were not so simple as Riemann's theory would lead us to expect. And it is not necessary to derive the three group from the two; it is more probably an original form, as original as the other.

The experimental results point conclusively to the priority of the dactylic form. The difference in number of errors in the readings by the younger children of the dactyl and anapæst was marked. The anapæst was far more frequently inverted and given as a dactyl, than the dactyl as anapæst. Bolton's subjects heard the first sound in the three-grouping as strongly accented. Occasionally, a subject found it easier to accent the second more than the first, but this did not seem to be the natural way. The reason given above for the preference of the trochee over the iambus would hold for the preference of the dactyl over the anapæst.

The process of inversion was best illustrated in anapæstic grouping; it was also much more frequent here. A peculiar arrangement of intensities which Ettlinger[1] cites in an altogether different reference can be best explained as a stage in the process of inversion. He affirms with Riemann that the greater intensity comes at the beginning and not at the end of the long syllable. Thus a grouping in the form $\overset{\prime\prime}{\smile}\quad \overset{\prime}{\underline{\underline{\geq}}}$ and $\overset{\prime\prime}{\smile}\quad \smile\quad \overset{\prime}{\underline{\underline{\geq}}}$ could arise from a strong tendency to give the first sound the greater intensity. These forms, in which temporal and intensive relations are in conflict, are not stable or regular forms, as Ettlinger seems to regard them. They are undoubtedly first stages in the process of inversion, which, if the rhythm were continued long enough, would finally give the more natural arrangement of the dactyl, in which the greatest intensity and duration are given to the same sound. Such forms as these frequently occurred in the rendering of the iambus and anapæst by the children, and were always then considered as cases of partial inversion. This also agrees with our observation that pitch and intensity are less stable than time; when inversion is not complete, pitch and intensity are the first to become inverted,—the accent then passing over to the first syllable,—while the temporal arrangement, being more stable, remains as at first; although it, as a rule, also shifted, if the rhythm were continued long enough, until the longest and strongest were no longer in opposition. Another and more common form of inversion, in which the temporal and intensive arrangement shifted at the same time, was apparently effected by a gradual change in the position of the pause; at no time in the process was there a conflict between the

[1] *Op. cit.*, p. 183.

intensive and temporal order. Eberhardt[1] has reported a similar occurrence: with the form  or  long repeated, the form  resulted. "Bei sehr langsamen Rhythmen verschwindet dagegen die Zusammenfassung mehr und mehr; an die Stelle der Trennung der Gruppen tritt ein allmaehliches Uebergehen von der einen Gruppe zur anderen, vermittelt durch das letzte Glied jeder Gruppe, auf; das letzte Glied wird dann als Auftakt angesehen und als solcher enger mit dem ersten Glied der naechsten Gruppe verbunden."

The form which Wundt[2] considers the earliest three grouping (the amphibrach) was never observed during the course of the experiment, either with children or adults; although, particularly with the adults, the possibility of such an arrangement was given, as will be seen in the later discussion of the method used. For this reason a special investigation with twenty-eight seventh grade children was made, in which this form among others was directly requested. The children were asked to emphasize the second and fifth syllable on each line. With one exception they invariably declared, before reaching the end of the first line, that they were unable to read it in that way, and being asked to try again threw the five lines either into a form something like this ⏑ — | ⏑ ⏑ — | ⏑ or ⏑ | — ⏑ ⏑ | — ⏑ | . Often, by avoiding a pause at the end of a line, they were able after a line or two to give the remainder entirely in a dactylic or anapæstic rhythm. Some could find no rhythm, and the result was a perfectly irregular rendering, with an occasional syllable louder and longer than the others. One child out of twenty-eight, a girl of twelve, gave the grouping without the slightest hesitation. She read unusually rapidly and in an animated manner. It might be conjectured that the children failed on this form because they had already practiced the other forms; but for this experiment children were selected who knew nothing of the previous experiment, in order that the effect of practice should not prejudice the results. The usual proportion of inversions was noted in the reading of the other forms. But even then, the disparity between the results for the anapæst (the most difficult of the three group), with four inversions out of twenty-eight readings, and the amphibrach with twenty-seven failures out of twenty-eight readings, proves conclusively the artificial and unnatural character of the latter grouping.

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[1] Zwei Beiträge zur Psychologie des Rhythmus u. des Tempo. Zeitsch. für Psy., XVIII, p. 126.
[2] Grundzüge der physiol. Psych., 1893, 4te Aufl., II, p. 86.

The results so far obtained are not in harmony with Miss Smith's statement[1] that there is no such thing as a poor rhythm; that rhythm either is present as a complete and perfect form, or vanishes entirely. There are, on the contrary, several clearly defined stages or degrees of rhythmical perfection or unitariness. While E. A. Poe, in his Rationale of English Verse, derives rhythm from an improbable source (the pleasure due to equalities; the simple ear preferring simple equalities, the practiced compound equalities), his order of genesis agrees in several particulars with that which the results of the experiment have led us to make. Poe regarded the rudimentary form of verse as the spondee; later came a collection of two spondees; a third step was the juxtaposition of three words; and monotony finally led to the employment of accent. But the experiments seem to indicate (1) that the earliest rhythm is even simpler than the two-group of Poe; that what has been termed the primary rhythm is the simplest and earliest form. (*a*) This is modified by the introduction of irregularly recurring accents. Boehme considers this the characteristic arrangement of children's verse.[2] "Das Kind kennt (wie das Volk) in seiner Ditchtung kein jambisches oder trochäisches Versmass, sondern zählt bloss die Hebungen, d. h., die betonten Silben in jeder Zeile; zwischen die Hebungen treten dann die Senkungen (die unbetonten Silben), je eine, oder zwei oder keine, denn die Senkung darf auch fehlen. Herrschend tritt ins Kinderreim das sogenannte trochäische Mass auf."

(2) Next in order comes the simplest two-group, the spondee; two syllables of equal intensity, duration and pitch, separated from the two following by a longer pause than that intervening between each pair of syllables. (*a*) A trochaic arrangement of the variants, *i. e.*, the accent on the first syllable. This has a number of possible degrees of perfection; in its completest form the last syllable would be subordinated to the first, not only in intensity, but also in duration and in pitch. (*b*) The second syllable accented or iambic arrangement of the variants. There is considerable variation in the results; for some the dactyl is undoubtedly easier than the iambus, but on the whole we should probably be justified in regarding the iambus as naturally preceding the dactyl.

(3) The three-group. The unaccented form is very rare; it is questionable if the group ever occurs without the presence of a very slight accent upon one syllable. (*a*) The dactyl is undoubtedly the simplest three-rhythm. (*b*) The anapæst comes next to the dactyl in order of difficulty. (*c*) The form

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[1] *Op. cit.*, p. 292.

[2] Deutsches Kinderlied und Kinderspiel, Leipzig, 1897, p. 8.

which Wundt regards as the original form of the three-group, if admitted at all, must be regarded as the most difficult. These are all three capable of great variety in arrangement through variations of the different objective factors.

2. The Objective Factors: Their Arrangement and its Significance.

To the mooted question of the importance of a temporal factor in rhythm, Lanier[1] replied that "primordial temporalness is always necessary," and again: "the office of accent cannot begin until after rhythm is established: when accent may be used to suggest various secondary arrangements of the primary rhythmic material; but this office is still absolutely dependent upon time or duration, the sole use of accent being that it recurs at stated intervals of time." Certain poetry, as Tennyson's "Break, break," is dependent for its effect upon measured silences, and must therefore be clearly independent of accent. "If the rhythm were struck by a machine incapable of intensity or pitch difference the rhythm would still be pleasing." Ettlinger[2] states that the order of grouping is always dominated by the temporal factor. These statements of Lanier and Ettlinger are quite different in their bearing. 'Primordial temporalness,' or in other words regularity of succession, characterizes even the simplest or the primary rhythm. Without it perception of rhythm fails (although Miss Smith[3] has shown that slight objective irregularities do not disturb the rhythm, she does not prove that subjective regularity of impressions was not present). Temporalness, in its connotation of regular succession, is the basal principle of rhythm. This, however, is quite another thing than saying that the character of the grouping is dependent upon the time order. Temporal changes can alone (intensity and pitch remaining constant) produce a pleasing rhythm, as has been shown in the results of the experiments; but intensive co-ordination (the temporal relations remaining constant) can also produce a rhythm. When time and intensity conflict, for example, when the shorter is the stronger, it is a question whether the long or the strong syllable will dominate the grouping. The results of the experiments on pitch would indicate that under certain conditions the objectively long may appear shorter and unaccented. Meumann says[4] that the long syllable because of its greater volume of sound draws the attention to it, and is therefore fitted to introduce a subjective accent. On the other hand, it is equally true

[1] *Op. cit.*, pp. 65, 103, 101.
[2] *Op. cit.*, p. 182.
[3] *Op. cit.*, p. 123.
[4] *Op. cit.*, p. 404.

that the objectively strong syllable, by virtue of that fact, is focused by the attention and receives a subjective accent. It would seem as if any change, either temporal or intensive, by the very fact of change and through the increased attention which it consequently receives, can bring about a subjective accent or stress. Then the factor, which is best suited to emphasize the fact of change, must have the greatest influence upon the character of the rhythm. Neither time nor intensity, as such, is a determinant of secondary rhythm; but either may be this when translated into terms of subjective accent or stress (*cf.* further discussion).

Position of pause. When several groups were compounded, a short interval followed each group, while a much longer interval followed the compounded group. The long pause with our subjects, as the synchronous readings from the microphone and pneumograph show, always occurred at the time of inhalation. The end of a group was marked by a pause longer than that which separated the syllables of the group. In the dactylic and trochaic grouping, this is the pause preceding the accented syllable. But the interval preceding the accented syllable in the iambic-anapæstic grouping was not always lengthened; although frequently a secondary pause occurred after the accented syllable in the case of the dactyl and before it in the anapæst. In the three-group, the two intervening pauses were ordinarily of the same length. There was still another arrangement noticed in the microphone readings; the first pause was shortest, the second longer, and the third longest. Several orders were observed, in the dactyl —— —— ———, —— — ———, — —— ———; and in the anapæst, — — ———, — —— ———. The second form gave a more unitary character to the whole group. It is the only order which Wundt[1] recognizes. "If in a long series of regular beats, single impressions are emphasized by their greater intensity or by some qualitative peculiarity, one uniform result is the overestimation of the interval preceding and following the emphasized beat." This lengthening is brought about through expectation and relief.—We cannot find Wundt's explanation satisfactory. For (1) at the rate at which sounds must follow each other to produce a rhythmical impression expectation and relief could play no part. Eberhardt[2] also says that expectation was never present according to his introspection when the rate of succession was less than one second, and then only occasionally present. (2) The arrangement of pauses, which this theory presupposes, is not by any means the

[1] Outlines, Eng. Trans., p. 150.
[2] *Op. cit.*, p. 109.

only one found, as has already been shown. The long pause occurred most frequently at the end of the group only, the intervening pauses being of nearly the same length. The lengthening of the pause appears rather to be conditioned by the changing of the attention; in the shifting of the attention from one sound to another there must be a psychologically empty time which we call a pause. The apparent lengthening of the pause following the accented syllable is a contrast effect between strong sound and succeeding silence.

Order of syllables. This was not constant. The different arrangements were correlated with clearly defined grades of unitariness in the total impression. In the dactylic grouping, with the microphone reading, the most frequent order was ——— ——— —; *i. e.*, the duration of the syllables gradually decreases. In the freer renderings of Method I the order was ——— — —; the second and third syllables were of equal duration. The order ——— — ——, in which the first was still equal to the sum of the second and third, but the second was shorter than the third, was frequently given. The order noted by McKay and Hurst[1] is the same as that which occurred most frequently in the microphone readings; this appears, on the whole, to be the least perfect arrangement; Meumann and Eberhardt give the order which has been noted as the least frequent but the most perfect. Bolton's[2] rule for the time order of a group of sounds is not substantiated by the results either with children or adults. His principle is that "a longer sound occurring regularly in a series imposes a grouping according to the number of sounds between the long ones. The long sound is as a rule the last in the group." The subjects must have confused the long sound and the long interval in their report.

Here, as in the ordering of the pause, the unitariness of the impression appears to be in proportion to the degree of contrast; thus the most unitary impression is given by the time order ——— — ——. When a group of syllables follow each other in the order Bolton gives, the primary rhythm is still prominent; the separate syllables or sounds are not subordinated to the group, as they are in the grouping just noted. The time relation of the accented syllable to the unaccented was never the relation of two to one, nor could it be expressed by simple numbers: *cf.* Tables. As a rule the accented syllable was but slightly longer than the unaccented. Neither did Wrinch and Shaw[3] find the definite time relations $\frac{1}{2}$ and $\frac{1}{4}$ as

[1] Experiments on Time Relations of Poetical Metres, Univ. of Toronto Studies, No. 3.

[2] *Op. cit.*, p. 231.

[3] Contributions to the Psychology of Time, Univ. of Toronto Studies, No. 2, p. 51.

they appear in musical composition. These results are not in accordance with Mach's statement:[1] "So far as I am able to judge, we recognize the identity of time ratios of two rhythms only when they are capable of being represented by very small numbers. Thus we really notice, immediately, only the identity or non-identity of the two times, and in the latter case recognize the ratio of the two only by the fact that one part is exactly contained in the other. Herewith we have an explanation of the fact that, in marking time, the time is always divided into absolutely equal parts." The fact that an intensive change may be substituted for a temporal and the feeling of equality not disturbed argues against Mach's theory. The facts of substitution and the analogous case of the influence of limiting stimuli upon the judgment of short intervals (intervals bounded by strong stimuli are judged longer than equal intervals bounded by weak stimuli) indicates that what we have is not a direct comparison of times but one of subjective stresses.

The Relative Time Values of the Restrained Forms. The total time for reading thirty syllables, in accordance with the four required arrangements, was taken in Method I by means of a stop-watch. The microphone readings are not comparable, as the number of groups given in any one series was indefinite, depending upon the number that could be recorded in one revolution of the drum. Consequently only the results of the readings by Method I have been tabulated.

The figures given in Table XLII represent the average time of the different classes. The asterisk marks the absence of members. The absence of an individual affected the average, increasing or decreasing the time, according to the time of the individual in question; the absences therefore give a greater appearance of irregularity to the results than really existed.

American children. There is a decrease in time required for reading a series corresponding to the age of the pupil. With the boys this holds throughout, from the first to the seventh grade, the change being greatest between the first and the fourth grades. This is undoubtedly due to the slower functioning of the attention in the case of the younger children. The times of the girls of the fourth grade were faster than those for the seventh in the reading of the trochee and iambus. The natural reaction time of the girls of the fourth grade was faster than that of the seventh, but the greater difficulty of the dactyl and anapæst for the fourth grade girls made their time for the reading of those forms slower than that of the seventh grade. The *m. v.* is greatest for the first grade. The effect of practice is not marked, but is most noticeable in the case of

[1] Analysis of Sensation, Eng. Trans., p. 118.

			Anapæst.						Rhythm.
	VII.		I.		IV.		VII.		Class.
	B	G.	B.	G.	B.	G.	B.	G.	
31	28.5	20.4	27.2	31.3	25.	20.5	21.	16.1	
26	19.9	17.8	27.5	35.	22.85	18.	22.25	16.45	
*27	19.8	17.36	*24.25	30.66	18.75	*19.53	19.6	16.6	
27	19.6	17.1	27.5	30.	18.7	17.14	20.2	15.5	
27	15.8	15.6	24.1	30.	18.5	*17.6	*18.05	15.9	
28	20.72		26.11		20.76		20.62		
M	M.V.		M.V.		M.V.		M.V.		
1	2.22		1.56		2.53		1.2		
		17.65		31.39		18.55		15.71	
		M.V.		M.V.		M.V.		M.V.	
		1.13		1.48		1.17		.61	

			Anapæst.						Rhythm.
	VII.		I.		IV.		VII.		Class.
B	B.	G.	B.	G.	B.	G.	B.	G.	
22	13.2	16.5	30.7	22.	15.1	21.3	11.05	15.5	
22	*12.	16.1	24.1	*20.	14.45	16.5	*11.5	15.1	
23	11.1	15.7	21.5	19.	13.5	*14.6	11.5	16.	
19	*12.	15.5	22.6	17.2	*14.6	13.8	*11.6	14.3	
21	12.6	*16.	21.7	17.8	13.	14.1	12.6	*15.2	
21	12.2		24.1		14.13		11.65		
M	M.V.		M.V.		M.V.		M.V.		
1.	.56		2.68		.68		.38		
		15.96		19.2		16.06		15.2	
		M.V.		M.V.		M.V,		M.V.	
		.24		1.24		2.61		.42	

the girls. In the involuntary grouping of the boys of the fourth grade the rate of succession in the later series is slower than in the earlier. The reason may be that because of its great regularity it offered less and less interest. Throughout, the times for the boys of the seventh grades are faster than those for the girls of the same grades. The values given for the boys and girls of the first grade do not represent the time values for the dactyl and anapæst, as they failed to produce those rhythms. In general, then, the three-groups are shorter than the two.

German children. The time values are much slower than for the Americans. With the girls the decrease in time required runs parallel with increase in age, but with the boys (excepting for the anapæst and iambus) the fourth grade read more rapidly than the seventh. The effect of practice is greatest in the cases of dactyl and anapæst. The results are not so unequivocal as with the American children. The three-groups are slightly shorter than the two-groups.

These results, as far as they go, are in harmony with the results obtained by other investigators. The inherent difficulty of the more complex forms for the younger children obscured the general principle. For a satisfactory comparison of the time values of the different rhythms, the investigation must be carried on with adults. It is, however, clearly shown that the times for the three-groups are shorter than those for the two-groups. The three-group divides the series of sounds into fewer unities and naturally shortens the time for the total series. Within certain limits the number of sounds in a group appears to depend upon the rate of succession. Bolton's Subject 2 says: "Slower than a certain rate no rhythm is felt. With more rapid rates two clicks form a group. Faster still four clicks form a group with the primary accent on the first, the secondary on the third, and an interval after the fourth; a still more rapid rate gives an eight group. At some rates I was able to get a three rhythm accented strongly on the first."

The fluctuation in results will not warrant a comparison of the results for trochee and iambus or for dactyl and anapæst. Hurst and McKay[1] found that the foot in the iambus and anapæst tended to be longer than that in the trochee and the dactyl; that the trochee and dactyl were therefore used more frequently for stirring and rapidly moving verse. Rate of succession had a similar effect upon several of our subjects, who in comparing the two and the three group discs found that the three-grouped (rate of succession being more rapid) were enlivening and exciting, while the two-grouped were dull. "With fast rates intensive changes recur more rapidly and hence call

[1] *Op. cit.*, pp. 166 ff.

for more rapid muscular movement. On this account fast rates were found to be exhilarating and animating, and slower drowsy and soporific." If expectation played any part in mediating the grouping, we should expect the iambus and anapæst to be shorter than the trochee and dactyl. That the opposite is the case is an argument against the expectation theory of Wundt.

Arrangement of Intensities. In the two-group the strongest and longest naturally come first. They can, however, have a second place. Only in cases of partial inversion are the longest and strongest separated. The lengthening of the accented syllable follows naturally from the greater muscular strain and increased attention which are given it. In the three-group (dactyl) there were several arrangements given dependent upon the more or less perfect subordination of parts within the group. The forms noted were (*a*) ———' —— —— or (*b*) ———" ——' —— or (*c*) ———" —— ——.' The arrangement (*a*) was very frequent, (*b*) less frequent; the most satisfactory form was (*c*). These results do not agree with those of Bolton,[1] who notes only form (*b*), and gives as a principle that, when series of impressions made up of three or four intensities recur in a sequence, they are so arranged that the impressions are subordinated to one another as nearly as possible from beginning to end. Bolton also finds four arrangements of intensities possible; but it is very doubtful if we can directly compare more than three intensities, and can therefore have more than three grades of accentuation in a group. Eberhardt[2] does not find the arrangement Bolton gives; on the contrary, he notes arrangement (*c*) as the most natural form of the three-grouping. This is certainly a closer grouping, and gives an impression of greater unity than form (*b*). In it, the first is accented by contrast with the second and the third by contrast with the second, and the whole group appears to form a closed circuit; while in the last form there is a feeling that there might be still another step in the graded series before the end is reached. In other words, the subordination of the whole group to the accented syllable is greater by this arrangement.

Pitch Relations.

The question now presents itself whether quality can be

[1] *Op. cit.*, p. 226.

[2] *Op. cit.*, p. 123. "Ferner sei über das Betonungsverhältnis des zweiten und dritten Gliedes bemerkt, dass die vom der Metrik verlangte Beto nung des zweiten Schlages gegenüber dem dritten nicht stattgeun den hat; im Gegentheil scheint es, als werde stets der dritte Schla minimal stärker betont als der zweite, wenn auch die Zahlen d dann vielleicht zu erwartende Verlängerung des dritten Gliedes nic durchgehends aufweisen."

called a determinant of rhythm in the same way and with the same degree of constancy as time and intensity, or whether it merely increases the intensive effect. As previously noted, the more frequent occurrence of P. and I. together, rather than P. and T., might be so interpreted. Meumann appears to be of this opinion.[1] "Accent is, finally, never a mere increase in intensity but also an increase in pitch; increase of pitch as well as of intensity appears to serve the purpose of bringing out the logically and emotionally more important." The stronger and longer tone was nearly always the higher in the spoken rhythm, though there were many more cases of inversion in pitch than in either time or intensity. Several children always spoke of the stronger tone as the higher (this was without suggestion on our part, and the remark was always left apparently unnoticed). Not infrequently the longer, higher and stronger was accompanied by a raising of the whole body. Meumann also remarks that high notes are apparently more intensive than low notes of the same intensity. A contrary statement is made by Abraham and Schaefer.[2] "Wie für die Analyse des Akkordes, so wurde auch für die Bestimmung des Rhythmus der tiefste Ton unwilkürlich als erster Ton gewählt, wohl in Folge musikalischer Gewohnheiten. Er schien stärker aus der Tonfolge herauszuspringen, so dass es Mühe machte, mit einem andern den Rhythmus beginnen zu lassen." There appear to be three possible interpretations of the facts; either pitch is not an independent determinant of rhythm; or, being such, the higher is the accented; or again, in accordance with Abraham and Schaefer, the lower is the accented tone. In order to gain a more satisfactory answer, another series of experiments was made. The first experiment gave the qualitative relations of the motor rhythm only; the object of the second was to determine qualitative relations in a sensory rhythm, to determine whether the higher and lower tones had a constant position in the grouping, or if their position was dependent upon some secondary factor. It was necessary for such an investigation to get a series of tones that should vary only in pitch. For this purpose an apparatus was devised in the psychological laboratory at Cornell University.

Apparatus. Two electrically driven forks cased in sound proof boxes were the source of sound. At first the c^1 of 256 and the c^2 of 512 double vibrations were used; but the interval was too large to be satisfactory, and the a^1 of 435 was substituted for the c^1 of 256. A resonator was placed just above each tuning fork. Rubber tubes led out from these resonators, and ended at some distance from the boxes in small

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[1] *Op. cit.*, p. 402.

[2] Ueber die maximale Geschwindigkeit von Tonfolgen: Zeits. für Psy., XX, p. 415.

pieces of glass tubing, which were securely fastened to two wooden standards. In front of these standards discs were revolved. On the opposite side of the discs, a^1 and c^2 resonators were adjusted so as to catch their respective tones; by means of tubing the tones were carried to the ear of the subject. Nine discs were used. *Disc (1)*. For comparison of subjective rhythm—if the subjects were so inclined—with the rhythms objectively caused by variations in pitch, this disc had two circular slots 90° long, 1½ cm. wide and 13 cm. from the center of the disc. These were on opposite sides of the disc. Thus the disc shut off the tone coming from the c^2 fork, allowing only that from the a^1 to pass through; as the tone was successively given and cut off, for an interval equal to the time required for the disc to make one-fourth of a revolution, the successive tones and intervals were of equal duration. *Disc (2)* had two slots, one of which was 4 cm., the other 13 cm., from the center of the disc. Each of these formed an arc of 90°; and the successive sounds and silences were of equal duration, but varied in pitch. *Disc (5)* was made for the comparison of the subjective rhythm with the objectively conditioned three-group. It had three slots of 60° each, 13 cm. from the center of disc. *Disc (6)* had three slots, two of which were 13 cm. and the third 4 cm. from the center. It thus gave two tones from the a^1 fork to one from the c^2. The duration of all the tones and intervals was equal, lasting for an interval equal to the time occupied by the rotation of the disc through 60°. *Disc (7)* had three slots; two 4 cm., one 13 cm., from the center. All arcs of 60°. The resulting rhythm was objectively composed of two tones from the c^2 fork and one from the a^1; these were of equal duration together with the intervening intervals. In order to ascertain if an increase in duration of one of the tones would change the rhythm already established, in *disc (3)* the slot admitting tones from the a^1 fork was increased, at first by an increment of 30°. Later 15° more were added. The resulting rhythm consisted objectively of two tones, that from the a^1 fork being one-half again as long as that from the c^2. *Disc (4)*. The same number of degrees was added to the slot admitting tones from the c^2 fork. The resulting rhythm was a two-group, the reverse of that given by disc (3). *Discs (8) and (9)*. The slots admitting the tones from the a^1 and c^2 forks respectively were increased at first by increments of 15°; later 15° more were added. The resulting rhythms were three-groups, in which one tone was longer than the other two.

The time occupied by one rotation of a disc was approximately one second. The chief difficulty with the above apparatus or with any, for that matter, which might be devised, was in the regulation of the intensities of the two forks. There was no means of objectively regulating the intensities; recourse for that reason must be had to a subjective regulation. This necessitated a preliminary experiment for each series.

Preliminary Experiment. The subject sat with back to apparatus and experimenter, and at some distance from the resonator. In order to avoid all suggestion of rhythm in getting the intensity judgments, the discs were not used. Instead, at the first signal one tone was given for three seconds, at another signal the other tone was given for an equal time; and judgment as to the intensity of the two tones was passed. After a few preliminary judgments (to ascertain the nature and direction of difference), it was possible by increasing or de-

creasing the amount of resistance to the current as the judgments might indicate, to reach a nearly liminal difference. The method of procedure was then in the main that of Right and Wrong Cases. When evidence was given, through constancy in the direction of judgment, that there was subjective difference in intensity, the resistance was slightly increased or diminished in accordance with the direction of judgment. This procedure was kept up until a series of thirty judgments was obtained, in which there was either no constancy in the judgment, or both tones was judged equal. This result warranted the presumption that there was no subjective difference in intensity. Nearly all the subjects experienced great difficulty, when giving their judgments, in abstracting intensity from quality. Some judged the higher tones as "nearer" and therefore louder; others the lower tones as "bigger" and consequently louder. For this reason the two forks first used were very unsatisfactory; with an interval of a minor third the difficulty was not so great, and near the limen a few of the subjects, who were decidedly unmusical, confused the pitch of the two tones as well.

Having then the conditions for the experiment (equality in time and intensity), we proceeded to use the discs. Sometimes the two-grouped were given first, at other times the three-grouped. Discs 1 and 5 were given sometimes before and sometimes after the others of their respective sets. But the two-grouped and the three-grouped were always given separately. It was found more satisfactory to let the subject determine the time for hearing each rhythm; he attended to each, until he was fully satisfied, and then reported immediately.

The subjects were Mr. I. McKay, rhythmical, no musical training, considerable training in introspection; Mr. W. McKee, some training in introspection, no musical training; Miss M. F. Winger, considerable training in introspection, unmusical; Mrs. E. V. Bentley, musical, some training in introspection; Mrs. B. Brooks, some training in introspection, no musical training; Miss E. Parry, some training in introspection, no musical training; Miss C. Seymour, some training in introspection, no musical training.

The subjects made their reports in such form of metrical notation as they might find individually convenient, and not in the form that appears in the Tables. They were thus able to give their report while the rhythm was in full swing. For the sake of clearness, the reports have been tabulated in the form given, and occasional interpretatory remarks of the subjects have been added.

Results. While there was no general constancy in the accentuation of the high or low tones, *i. e.*, no constancy for *all* individuals, there was a marked constancy in the interpretation of the *same* individual throughout the different series given. Some individuals were inclined to hear the high as the more intense, others the low. The subjects may be divided

TABLE XLIV.

Three-grouped rhythm; c of 256 vib. and a of 453 vib. All tones and intervals of equal duration with the exception that a in disc 8 and c in disc 9 are increased by a temporal increment of 1-4.

Disc no.	5.	6.	7.	8.	9.
Objective Rhythm.	a a a a a a	a cc a cc a cc	c aa c aa c aa	*a* cc *a* cc *a* cc	*c* aa *c* aa etc,
Subjective. B. B.	No grouping.		Lowest last in group; both high tones accented; the first high is longer than the second, also stronger.		
I. M.	A two-group; the first tone slightly longer and stronger than the second.	The higher is first and is longer. The two low are of about equal duration. The first is separated by a long interval from the second.	At first the lower tone has the first place in the group; later it has the last place. The lower tone is longer and is accented.	Rhythm same as with disc 6; the high tone has a stronger accent than in that rhythm.	The two high tones are longer and are accented; but the low tone has first place in the group.
W. M.	No grouping — but if I think of the clock, the tones are grouped in a two-rhythm and the first is accented,	The higher tone is first; is *longer* and is accented.	Two distinct parts to each group. The two low tones are shorter and are separated by a long interval from the higher tone which comes last, although longer and accented.	Rhythm much same as with disc 6; but interval between 1st and 2d tone is quite long.	Much same as 7; but not so pleasant; it does n't hold together as well.
F. W.	Can group by 8s or 4s.	The higher tone is first; it is longer and stronger. The two low tones are of equal duration and intensity.	The first tone is lower, is shorter, but is accented; the second and third tones are longer than first and are higher; and at last the accent is placed upon the two higher tones.	The first tone is higher, is longer and is accented; the second and third appear to be of equal duration, intensity and pitch. Long intervals follow the first and third tones.	The first tone is short and is low. The second and third are longer and higher, the second is accented.
C. S.	A two-rhythm.	The first is longer and stronger than the second and third.	Finds no pitch difference; the first is longer and is accented,	Same rhythm as with discs 6 and 7.	

TABLE XLVI.

Three-grouped rhythm; a of 453 vib. and c of 512 vib. All tones and intervals of equal duration with the exception that c in disc 8 and a in disc 9 are increased by a temporal increment of 1-4.

Disc no.	5.	6.	7.	8.	9.
Objective.	a a a a a	c a a c a a	a c c a c c	*c* a a *c* a a	*a* c c *a* c c
Subjective. B. B.	A two-group; first longer and more intense.	The longest and lowest is last; it is least intense, the second is most intense.	The highest is first, it is longest. It appears to sound through the others like the air to a bass accompaniment.	The first is highest, longest and strongest. The second and third have same pitch, duration and intensity.	The highest is longest and most intense; it may be either first or last in the group. (High and low are confused.)
I. M.	A two-group; but no distinguishable difference in tones.	The highest is first, but second and third are longer and more intense. The second is longer than the third.	The lowest is first, it is longest. Second and third are of equal duration.	Same as rhythm of disc 6.	Same as with disc 7.
W. M.	No grouping, even with great effort.	The highest is shortest; it may come first or last. The other two are longer and more intense and equally so.	The two higher are shorter but are both accented. The lower tone comes last in the group.	Same as rhythm of disc 6.	Same as 7. Both 7 and 9 are annoying and unstable.
F. W.	All alike; but can arrange in any grouping; when subject gives up to rhythm, it falls into groups of twos.	The higher tone is first; it is more intense, but the two lower tones are longer.	The higher is first, longer and more intense. The second and third are lower and of equal duration and intensity.		Same as 7.
E. P.	A four-rhythm broken into groups of twos.	The higher is shorter and comes last; it is separated by a long interval from the second. The first and second are of equal duration and intensity.	The higher is first and more intense than the second and third, although it is shorter. The two lower are of apparently equal duration and intensity. (High and low are confused here.)	Rhythm same as with disc 6.	Same as 7, except that the first and most intense tone is also the longest.

TABLE XLVIII.

Three-grouped rhythm; a of 453 vib. and c of 512 vib. All tones and intervals of equal duration with the exception that c in disc 8 and a in disc 9 are increased by a temporal increment of 1-2.

Disc no.	5.	6.	7.	8.	9.
Objective.	a a a a a	c a a c a a	a c c a c c	*c* a a *c* a a	*a* c c *a* c c
I. M.	A two-group. The first tone is a little louder and longer; but this difference may be destroyed by analytic attention.		The higher is longest and most intense; it is first. The other two are of equal duration and intensity.	Same as 7.	This seems different; but can't tell in what the difference consists.
F. W.	Most pleasant grouping is by eights, can group by fours, threes or twos.	The higher tone is first; it is shorter, although more intense than second and third. The second tone is longer than the third.	The higher tone is longer and more intense, than the two lower tones. (Confusion of high and low.)	The higher tone is first, is longer and more intense. The shortness of the interval after the first makes the dis seem in a hurry.	The higher tone is last but is longer and more intense than the two lower. (Same confusion here.)
E. P.	Same tone; group of eight broken into fours. Primary accent on second tone, secondary on fourth.	All tones are of same duration but the higher is more intense.	The higher is longer and more intense, and first in the group. The second and third are of same pitch, duration and intensity. (Evident confusion of high and low.)	All tones are of the same intensity and duration; the first tone is the higher, the second and third are of same pitch and lower than first.	Same as 7. (Confuses high and low.)
E. V. B.	A four-grouped rhythm; first group accented; unpleasant by contrast with other rhythms.	Two lower tones are longer and more intense than the higher; the first of these is longer and more intense than the second. High tone is last.	The low tone is longer, stronger than the two higher which are of equal duration and intensity. This rhythm is pleasanter than 6.		Resembles rhythm of disc 7. All tones of equal duration.
E. V. B. On second hearing.	Something like 1, but higher, quicker and brighter.	Report same as on previous day.	Report practically same as on previous hearing. No interval between second and third tones.	Rhythm same as with disc 6. (High, although objectively longer, is heard as shorter.)	Same as rhythm of disc 7, except that the difference in the duration of the accented and unaccented is much greater than in that case.

into three classes,—those who accented the high tones, those who accented the low, and those to whom highness and lowness, as such, were a matter of indifference. With these subjects, in the three-group the accent fell upon the tone which was different from the other two in the group: c^1 *a a* or a^1 *c c*; *i. e.*, either *c* or *a* might be accented. The constancy with which the low tone was accented in the case of E. V. B. was very marked. With Disc 6, where the objective arrangement gave two low tones and one high, had there been no constancy in her interpretation of difference in pitch, the high tones as different from the other two would have been accented. On the contrary, she accented and lengthened the *first low* in both series given. In the case of Disc 8, the results show in a most striking manner a natural tendency to accent the low tone; here *c* is objectively lengthened, being one-half again as long as either *a*; it also, as in the arrangement of Disc 6, occurs but once in every three tones. It would seem in this case that the objective conditions must of necessity determine the rhythm. But, on the contrary, the *first a* is heard as *longer* and stronger. In Disc 3 the high tone is objectively longer. E. V. B. still gives the accent to the low tone, although the high is judged longer. For this subject, pitch is not only a constant determinant but also a more effective determinant than time, as judgments upon Discs 3 and 8 show. E. V. B. had had a considerable musical training; in fact she was the only 'musical' subject.

W. M. showed the same tendency. Where the interval was only a minor third, the low tone was invariably subjectively lengthened, and with but one partial exception accented. Even in the case of Discs 6 and 8, the subjective rhythm was the same as for *E. V. B.* With Disc 3, although the objective lengthening of the high tone resulted in giving it the first place in the group, the low tone was judged longer and more intense. But with the larger interval, the subjective rhythm for Disc 6 corresponds with the objective order; although the high tone was subjectively accented, it was (curiously) judged as lower. With Disc 8 not only the high but also the first low was accented.

E. P., although she almost invariably judged high low and low high, was strongly inclined to accent the objectively low, even though the judgment resulted in a seemingly distorted rhythm.

Other subjects were fully as determined to accent the high. *F. W.* was typical of this class. In her preliminary intensity judgments it was necessary to make the high tone considerably weaker than the low (on the basis of the judgments of the other subjects) in order to get a judgment of equality. As a

rule, the high tone came first in the group. Disc 9, when arranged in accordance with the objective order, was said to be unpleasant; this was undoubtedly due to the compulsion which the objective lengthening of a low tone (and the arrangement one low to two high) exerted upon F. W.'s natural grouping. Here, as with *W. M.*, high and low were confused. When F. W. accented the low tone, she called it the high. The tendency of C. S. was in the same direction. One great difficulty in interpreting the results for the two-group was the determination whether subjectively high and low corresponded to objectively high and low; in the three-group the arrangement of the three tones gave a basis for determination. When confusion of judgment was found in the three-group, the presumption was that it was present also in the two-group.

B. B. and *I. M.* were examples of the third type. Pitch was for them not a constant determinant of rhythm. The subjective order was determined by change of any sort; in a three-grouping consisting of two high and one low, the low was accented; but if the arrangement gave two low and one high, the high was accented. "Awareness of change" seems for these subjects to be the determinant of rhythm.

In the light of these equivocal results, how are we to interpret the great constancy with which the accented tone in a motor rhythm was raised in pitch? It will be remembered that cases of inversion in pitch were more frequent than in time or intensity; but even then the percentage was very low. What does increase in pitch mean for the producing subject? *An increase of intensity is quite probable, because of the necessary increase in the force of a blast of air to produce a heightening of pitch.*[1] This is in perfect accord with the results of the experiments on the motor rhythm, in which intensive and pitch differences were nearly always correlated. Pitch, then, is a constituent and constant factor in the spoken rhythm, but not necessarily as a qualitative determinant. Because of physical and physiological conditions it is an accompaniment of any intensive change. It is only an intensification of the intensive factor. In the sensory rhythm, the criteria of the spoken rhythm (strain sensations and tension in the trachea and vocal organs) were absent, unless there had been strong associations set up. Neither was there a physical or physiological reason for the constant appearance of variation in pitch. Pitch in the sensory rhythm owes its direction and constancy, when they are present, to the character and force of the individual associations. Where, as with E. V. B., musical training has given strength

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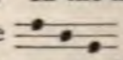
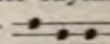
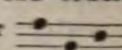
[1] Text book of Physiology, edited by E. A. Schäfer, 1900, Vol. II, p. 127.

and constancy to the association, we find that pitch has great effectiveness as a determinant of rhythm; but with subjects who have few associations of an unequivocal character, pitch as such can scarcely be said to determine the rhythm. It is not necessary that the association be of a musical character for it to have considerable constancy. The associations were very frequently of a spatial character; high was "nearer," low was "farther away;" low was "big," and high was "thin." One subject spoke of the high tone as "a silly little appendage." Still another subject was governed largely by spatial associations of another character; he placed the high tone in the top of the head, the other at the base of the skull, and experienced a 'flipping' from the one position to the other as the tone changed.

We can, then, say that quality is not an independent determinant of rhythm; it can be considered either as a substitute for or as an intensification of intensity,—whether because of strain sensations common to both, or because of associations which, reduced to their ultimate grounds, are of an intensive character.

In the arrangement of the tones as to pitch, owing to objective conditions (only two forks being used), the order was necessarily either high-low or low-high. Both of these occur with nearly the same frequency. In the motor rhythm, the orders for the three-group were  or  or , of which the third was the most pleasing; probably for the same reason that intensities arranged in a corresponding manner ——" —— ——' give a more pleasing impression. Such a group has a more unitary character. It would be interesting to obtain the judgments of adults as to the more or less satisfactory character of these different arrangements; but the necessary time was wanting.

The subjects, when questioned as to the course of the attention and its effect upon the rhythm, were unanimous in declaring that they attended to a group as a whole; it was the unit of attention. This tendency was so strong that it was frequently difficult for subjects to analyze what they had heard, although they 'felt' differences between the various rhythms. With E. V. B. it was always necessary to reproduce the rhythm by humming it before she could make an analysis.

Some of the remarks of the different subjects with regard to attention are given below. B. B. "The sounds were all loud at first, then became less distinct for a brief space, after which they were stronger again." "I tried to keep the sounds from growing fainter by concentrating the attention upon them, but succeeded only in prolonging the stronger." I. M. "The unit of attention was the foot; the character of the foot was determined by the accent of the syllable which

was the center of attention." "An attempt to inhibit the muscular movements makes the whole rhythm appear more uniform. The withdrawal of the attention seems to obscure the rhythm and cast it out of consciousness. I do not think the rhythm would disappear if I could attend to the tones and at the same time inhibit my movements." E. P. "The natural course of attention is from group to group." W. M. says of Disc 9: "When attention wavers the pattern can be changed, the different forms come and go rapidly." E. P. "Attention was upon the melody in general, but occasionally when analysis was somewhat difficult or combination unpleasant the attention wandered off to the separate tones, their duration, quality, etc."

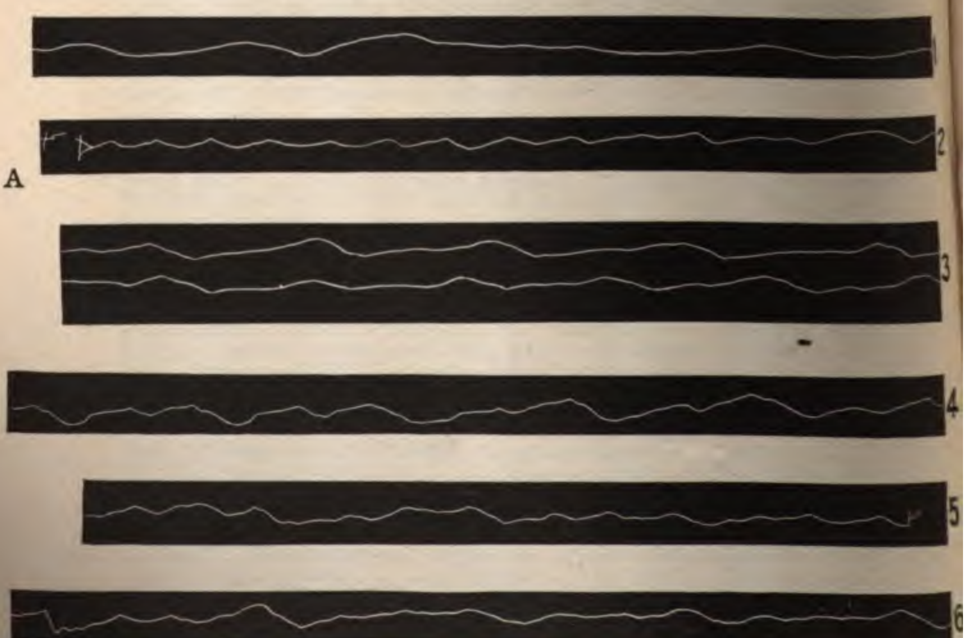
Accent. The subjects were not questioned as to the nature of their subjective accent; but finding interesting data on that point in their reports, data bearing upon the whole question of perception of rhythm, we collated them and give them with the name of the subject.

I. M. says with regard to Discs 5 and 6: "It is impossible to tell where the stress is in the feet. When I pay attention to intensity, pitch and duration they appear to be equal in each; so that the stress does not appear to lie in any one of them. There are of course the muscular sensations, but it is difficult to believe that there is not an objective rhythm." F. W. says of Disc 3: "The two tones take the accent equally well. The high one because it naturally comes first and seems to give the push or impulse to the whole thing. The second note could take it because it seems to be stronger and has a longer interval after it; I can change the accent at will." I. M. says with regard to Disc 1: "When I succeed in obtaining a rhythm, the first is more stressed and a little longer than the second, in which case there also appears to be some difference of quality but not of pitch." He says of Disc 3: "The high tone appears to be given with an inspiration, which is long, the low with an expiration, which is rapid, full, and stronger." E. P. says of Disc 2: "The higher is accented, but both are of approximately equal intensity." And with regard to Disc 6: "The three tones are of equal intensity but the accent falls on the two low tones." F. W. says of Disc 4: "Not easy to accent, but a little easier to accent the long. I can put it on the high and short, but do not like it so well. Moving the fingers helps placing of accent." With regard to Disc 1: "I cannot accent it. Tried to place it but it fell on all." On the same day, she says of Disc 2: "Main accent is on the long, but short and high is slightly accented too." With regard to Disc 6: "Perhaps the strongest accent is on short and high. Can put it on the first long but not on the second long." B. B. says of Disc 4: "The low tone is longer and usually more intense; sometimes the high seemed more intense; could change the accent by attention."

The cases of divided accent are interesting as showing that the unity of the total impression is dependent upon the objective correspondence of the most intense and longest, or at least that they stand in such a relation that they offer no objective hindrance to such a subjective interpretation. The reports of the several subjects show that accent is not dependent alone upon the objective relations of duration, intensity and quality; accent is subjective and changes with the attention. This seems to be the explanation of the facts of substitution. An objective condition which arrests the attention, be it either

through a lengthening of the tone or through increased intensity or a qualitative change or what not, is subjectively stressed or accented, in that it is thereby brought into the focus of attention. The effect of this accent of attention can be increased (*a*) by organic rhythms, sensations vibrating in unison with the attention rhythm; (*b*) by a rhythm in the affective tone. One subject, when asked to inhibit the concomitant movements, reported four distinct elements in the subjective rhythm; (1) gross up and down motions of the body; (2) resistance rhythm, due to attempt to inhibit movements; harder to resist movement in case of high tones; (3) rhythm of attention; (4) affective rhythm, indifferent-tranquil (low tone) and unpleasant-irritating (high tone). Ruling out the second factor, which arose from the special conditions, we have here two rhythms running parallel with the attention rhythm. The subject might also have added another, *i. e.*, the organic rhythm. To be sure, all these factors may not be present, although in the most perfect rhythm they are all found, fused to a total rhythmical perception.

CHAPTER III. MINOR PROBLEMS.



A

TABLE XLIX (*d*).

Averages for breathing during dactylic grouping.

	Expiration.			Inspiration.			Height.		
	a	b	c	a	b	c	a	b	c
	.63 sec.	.528 sec.	.559 sec.	.256 sec.	.283 sec.	.328 sec.	3.1 mm.	3.6 mm.	3.9 mm.
	.554 "	.503 "	.548 "	.3 "	.273 "	.352 "	2.71 "	2.2 "	2.5 "
	.554 "	.407 "	.473 "	.258 "	.317 "	.463 "	2.34 "	2.39 "	3.5 "
	.49 "	.463 "	.584 "	.321 "	.287 "	.253 "	3.62 "	3.06 "	3.47 "
	.515 "	.406 "	.497 "	.276 "	.281 "	.306 "	3.37 "	3.25 "	4.18 "
Aver.	.548 "	.481 "	.532 "	.282 "	.288 "	.342 "	3.03 "	3.1 "	3.5 "

TABLE XLIX (*e*).

Averages for breathing during anapæstic grouping.

(Breathing for several series was the same as for involuntary grouping. Others are given.)

	Expiration.			Inspiration.			Height.		
	a	b	c	a	b	c	a	b	c
	.646 sec.	.64 sec.	.72 sec.	.33 sec.	.37 sec.	.49 sec.	2.8 mm.	2.7 mm.	4.7 mm.
	.532 "	.628 "	.643 "	.228 "	.246 "	.609 "	—	—	—
Aver.	.589 "	.634 "	.681 "	.279 "	.308 "	.549 "			

had a mean duration of .373 sec. The average height did not vary perceptibly from that given for involuntary grouping. We have in the case of the trochee the only instance, with the exception of one iambic reading, in which one expiration had a duration equal to that of a group in the spoken rhythm. It is also noteworthy that the trochaic was the only grouping in which *R. A.* succeeded in giving a completely unitary character to the group. Here we have an illustration of the effect of the rhythmic perception upon the breathing; *i. e.*, with the

trochee, the most natural form of rhythm, the group was perceived as an unit, and the breathing took on the same character; with the iambus, dactyl and anapæst, the breathing curve is of a peculiar character. Here, although an expiration corresponded to each syllable and an inspiration to each pause, wherever there is a subordination of syllables to the group it is shown in the respiration curve; for example, in the dactyl each group of the respiration curve is divided into three smaller parts, in which the longest expiration corresponds with the first syllable, the shortest expiration and least excursion with the second syllable, and the medium long and high with the third. A complete failure to produce the rhythm was shown quite as clearly on the breathing curve as on the rhythmic, by a primary type of breathing. The respiration curves for the iambus, dactyl and anapæst bear evidence in the case of *R. A.* to an imperfect perception of rhythm; while the relation of the syllables to each other was perceived, the whole was not an object of immediate time perception as with the trochee. We have rather a series of perceptions which are compared with one another.

TABLE L (*a*).—*H.*

Averages for breathing during involuntary grouping.

	Expiration.	Inspiration.	Height.
	6.13 sec.*	.3 sec.	16. mm‡
	3.9 " *	.3 "	9.7 "
	4.6 " *	.268 "	? "
	4.55 "	.319 "	4.68 " §
	2.66 "	.291 "	9. "
	4.268 "	.3 "	8.66 "
	3.918 "	.288 "	6.75 "
Average,	4.289 sec.	.295 sec.	7.46 mm.

*Another subject.
‡The excursion of the tambour was changed after this series.
§The first record for *H.*

TABLE L (*b*).

Averages for breathing during trochaic grouping.

	Expiration.	Inspiration.	Height.
	4.2 sec.	.266 sec.	6.33 mm.
	3.506 "	.293 "	4.1 "
	4.86 "	.308 "	6 "
	4.436 "	.325 "	4 "
Average,	4.35 sec.	.298 sec.	5.8 mm.

A

Averages

Average,	

Average.

Average,	

Averages

Average,	

Averages

Average,	

TABLE LII.

Averages for several series of normal breathings.

	Expiration.	Inspiration.	Height.
C. D.	2.175 sec.	1.51 sec.	7.65 mm.
H.	2.165 "	1.975 "	14.25 "
K. A.	.96 "	.72 "	2.89 "

With *H.* and *C. D.*, the perfect correlation between the rhythms of speech and of respiration seen in *R. A.*'s reading was not found. One expiration included from six to ten syllables; thus one breathing curve covered several groups. The only difference between respiration during the free readings and the trochaic, iambic, dactylic or anapæstic readings was the greater height of the curve during the free reading.

Comparing these curves with the normal, we find in the case of *R. A.* that the respiration time, both for expiration and inspiration, is shortened, and the height increased. (The trochaic grouping is an exception, but here her breathing curve approximated that of *C. D.* and *H.*) *R. A.*'s normal breathing was very superficial, and became somewhat deeper in speaking. With *H.* and *C. D.*, on the contrary, the expiration time during reading of the rhythms is considerably longer than the normal, while inspiration is markedly shorter, and height is very noticeably decreased. The change in *R. A.*'s breathing is an example of the general rule that exercise increases the depth and frequency of respiration. The reason that her rhythmic respiration curve is thus typical of the respiration curve for exercise is probably to be accounted for by the fact that the perception of the rhythm as such had slight influence upon the respiration, *i. e.*, the purely physiological factors present in increased activity were the important elements. But with *C. D.* and *H.* this general principle is completely neglected. We must look for some other factor which has reversed the results. This factor we can reasonably presume to be an important element in the perception of the rhythm, since it occurs only in the case of *H.* and *C. D.*, with whom the perception of rhythm is much more perfect than it is with *R. A.* It is undoubtedly a psychical factor, since there has been no change in the physiological condition that would bring about such a startling reversal of the general rule. The curve appears in the main to agree with that given by Lehmann[1] for strongly concentrated attention. In general, then, the lengthened expiration and decreased height of the curve would seem to indicate an attentive state in which the attention was directed forward. The great regu-

[1] Die körperlichen Æusserungen psych. Zustände, 1899, pp. 68 ff.

larity of the curve, and the subnormal height, point to the absence of any affective element. Lehmann, in his discussion of expectant attention, or in other words an attention which is directed forward ('expectant' has been used so frequently to connate a conscious state with a strongly affective tone that it seems well to avoid the term in this case) says: "Zu den Affekten oder Stimmungen kann man diesen Zustand nicht rechnen, weil er im Allgeminen night gefühlsbetont sein wird." Bolton's Subject D. was inclined to refer all his time judgments to what he considered his natural rate of breathing; but rate of breathing, as experiments have shown, is not a constant factor in terms of which a judgment could be made; it is much more likely to take on the tempo of the rhythm than *vice versa*.

One might perhaps seek to explain the peculiarities of a respiration curve by the necessary changes accompanying regular speech; but we should hardly in that case find such pronounced individual differences in the curves. Moreover, it has been found by others that the hearing of rhythm affects the breathing. One subject, in the series taken with adults, said upon hearing Disc 5 immediately after the two-group that she found her breath coming faster as she listened to it.

No record was taken of the changes in the pulse, but it is probable that the change in the pulse follows from the change in breathing, and is therefore of secondary importance. Bolton's Subject 4 reported that the click which came nearest to the heart-beat seemed always to correspond with it, and that those coming between formed a group.

§ 2. Concomitant Movements.

There are other movements which, under certain conditions, frequently accompany the hearing or production of a rhythm; but these have neither the constancy nor the universality of the respiration and pulse rhythms; yet, as their presence or absence together with other characteristics of rhythmical grouping bears on the general question of the nature of rhythmical perception, they have been noted, together with the conditions under which they arose. Movements of this sort were scarcely ever present in the experiment with the microphone, while they were very frequently present in the freer readings of Method I. They were also remarked by nearly all of the adult subjects upon certain occasions. Many of the movements were apparently closely connected with the breathing.

In the reading of the German children the accented syllable was often spoken with a strong expiration which threw the head forward. Nearly all of the concomitant movements of the German children were of this sort. As they were closely con-

nected with the breathing, they could not be classed in the same category with those movements which are not necessitated by speech, but are clearly the response of the body to the rhythm. For example, tapping with the hand or foot.

TABLE LIII (*a*).

Concomitant Movements of the German Children.

	Expiratory.	Pendular.	Upward.
Trochee.	27	6	7
Iambus.	28	3	3
Dactyl.	20	6	7
Anapæst.	26	6	4

Although the movements in far the greater number of cases were merely expiratory, there were frequent occurrences of a pendular movement; also a raising of the body, which was always found together with a rising pitch. In this connection it is to be noted that Subject I. M. found the tendency to movement stronger upon hearing the high tones than the low. F. W. also said that there was an involuntary twitching of the eyelids upon hearing the high notes.

The movements of the American children were greater in variety, freer, and less obviously the result of changes in respiration.

TABLE LIII. (*b*).

Concomitant Movements of the American Children.

	Expiratory.	Pendular.	Upward.	Nodding of head.	Foot and hand.
Trochee.	8	20	13	43	8
Iambus.	10	13	22	31	8
Dactyl.	5	13	13	48	9
Anapæst.	4	2	23	25	6

Absence of movement was generally correlated with imperfect grouping; only two apparent exceptions were noted in the total number of readings for all classes and grades.

Adults, when pendular movements were present, frequently spoke of an association with the clock. Bolton notes the same fact.

What is the character of these concomitant movements? All, except those directly resulting from respiration, are unnecessary to the motor rhythm, and more emphatically so to the sensory. A few, such as the pendular, seem to be due to associations with external objects or with movements of the body. One fourth grade boy, when told what he was to do, was reminded of the movement of beating time. Subject W. M. found that he accompanied the auditory rhythm with movements of

the muscles of the throat, and that during the course of the hour the throat tired noticeably.

There are other concomitant movements which are not so readily subsumed under the principle of association. They seem rather to be of the nature of diffusive movements due to excessive excitation. Lehmann[1] explains them thus:

"Es liegt nun einmal in der Beschaffenheit der Nervensubstanz selbst, dass jede hinlaenglich starke Reizung eines Sinnesnerven eine Bewegung hervorruft, die sich nach dem übrigen Teilen des Nervensystems fortpflanzt. Diese Fortpflanzung, Irradiation, kann im entwickelten Bewusstsein durch willkuerliche Hinrichtung der Aufmerksamkeit gewöhnlich in bestimmter Richtung geleitet werden; ist der Reiz aber zu stark, oder tritt er so plötzlich ein, dass die Aufmerksamkeit nicht sogleich die richtige Richtung einschlagen kann, so wird die Irradiation wahrscheinlich nach allen Seiten vorgehen. Trifft die Bewegung dann die motorischen Zentren, so ruft sie eine vermehrte Innervation mithin eine Kontraktion der mit dem betreffenden Zentrum verbundenen Muskulatur hervor." Are these movements, both the associative and the diffused, of the nature of expressive movements, or are they to be regarded as means by which a difficult activity is reinforced? The facts observed would bear out either of these presumptions. One first grade boy failed on the complex forms, returning every time to a primary rhythm. We asked him to accompany the spoken rhythm with a clapping of the hands, and he succeeded in producing a dactylic rhythm with marked time and intensity differentiations, but 12 sec. slower than the reading he had previously given. F. W. moved her fingers to the rhythm, in order to place the accent when she was not sure of it. W. M. says: "When attention began to flag there was a tendency to keep the time by bobbing the head." I. M., very rhythmical and prone to accompany all sensory rhythms with some bodily movement, when asked to inhibit them and notice the effect on the rhythm, found that the rhythm was much obscured; but he was not sure whether the obscuration arose indirectly, through the focusing of the attention upon the inhibition of the movements instead of upon the rhythm, or directly, as a consequence of their inhibition. On another day he reported: "I observed a sidewise movement of the head. I think it was by this equal pendular movement that I judged the duration. I also observed that by stopping the movement the rhythm disappears more than on any other occasion." (With the Disc employed the tones were all of equal duration, intensity and

[1] Die Hauptgesetze des menschlichen Gefühlslebens, Leipzig, 1892, p. 292.

pitch; thus the rhythm was entirely subjective.) Bolton's subjects found difficulty in maintaining the grouping if they restrained these movements.

On the other hand, the children do not appear voluntarily to accompany the spoken rhythm with movements of this nature until they have acquired considerable facility in producing the rhythm.

Miss Smith[1] makes an interesting inference with regard to the concomitant movements. She believes that the reason we have come, in our civilized state, to pay less attention to the rhythm and more to the content in operatic music is that we sit and listen, and do not move with the rhythm. She thus makes movement the primary factor in rhythmical perception. Meyer[2] also believes that rhythm can be directly sensed only through bodily movement. Meumann (p. 261) regards the relative importance of the different modalities for rhythmical perception as determined by their relation to time estimation. The closer their connection to time estimation, the greater is their importance for rhythmical perception. The most important in that case are the auditory sensations, since they are almost exclusively the source of time estimation. The movements, then, are much less important for the perception of rhythm, since they also serve us in estimating spatial relations; and least of all in importance are the visual sensations, since they have little connection with time estimation. But the weight of evidence from the facts of introspection and observation does not bear Meumann out in this respect. Subjects have been found, who, while unrhythmical, were able to estimate time most accurately. *Cf.* Miss Smith.[3]

Several primary teachers were questioned as to how the children learned new songs. The answers were unanimous that the children first learned the tempo by the beating of time with hands or feet. Wundt[4] says: "Von unserer Bewegung her, in der wir das Rhythmische am frühesten finden, nennen wir daher den Rhythmus überhaupt eine nach genau bestimmtem Mass fortschreitende Bewegung. Aber in der Feinheit, mit der es die Schritte der rhythmischen Bewegung auffasst, übertrifft dann unser Ohr weit die ursprünglichen Bewegungsempfindungen." Buecher,[5] after his exhaustive study of primitive music, concluded: "Ohne rhythmische Körperbewegung kommt der Gesang bei diesen Völkern überhaupt nicht vor." In the primitive dances, as well as those of children, where the

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[1] *Op. cit.*, p. 297.
[2] Beiträge zur deutschen Metrik, '97.
[3] *Op. cit.*, p. 289.
[4] Grundzüge, II, p. 91.
[5] *Op. cit.*, p. 44.

rhythm of the dance, the clapping of hands, are combined with rhythmic sounds from an instrument, the acoustic rhythm can be regarded as secondary to the rhythmical bodily movements.

There is also an apparent priority in the development of the different rhythmical movements. The clapping of hands and stamping of feet are earlier than rhythmical speech. None of the American boys of the first grade could succeed in producing a rhythm more complex than the trochee. Some of them failed even in that. Four out of five of these boys were present on the day that we tested them on ability to clap the same rhythms, and also the power to keep a given tempo in marching.

R. cannot keep time in marching, although he claps all the rhythms successfully.

E., colored, marches in perfect time; has no difficulty in clapping any of the rhythmical forms.

S. succeeds for a while in keeping step, then misses it; succeeds with trochaic and iambic, but fails completely with dactylic and anapæstic forms.

H. marches in perfect time, and gives all the forms without the least hesitancy. This is in striking contrast with his inability to group the syllables in the same rhythmical order.

Hancock,[1] in a study of motor ability, tested one hundred and sixty children from five to seven years of age on ability to beat time. They were all successful with double time; treble and quadruple were more difficult; but all save fifteen were successful in beating these. As not more than two minutes were taken for each test, it seems reasonable to suppose that with ten or fifteen minutes of careful training all could succeed. Buecher[2] says: "Der Bewegungsrhythmus ist also die Ursache des rhythmischen Verlaufs der Sprachlaute, und wir dürfen vorläufig annehmen dass Letzterer ohne Ersteren möglich ist." Later, Bücher acknowledges that the gap between rhythmical movements and rhythmical speech is too wide to make it probable that the latter was derived solely and directly from the former. He therefore presumes that rhythmic speech arose partly as an imitation of the regularly recurring noises made by industrial implements (p. 308). It is difficult, however, to see wherein a causal connection between the two can be made out. On the contrary, it seems more probable that the larger rhythmical movements precede rhythmical speech, only because in the one case the co-ordinations are grosser, in the other finer and more complicated. The rhythmical nature of both resides in the regularity with which all bodily movements tend to follow one another in a healthy organism.

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[1] A Preliminary Study of Motor Ability, *Ped. Sem.*, III, p. 18.

[2] *Op. cit.*, p. 55.

The presence of rhythmical movement does not, as Meumann has pointed out, warrant the presumption that the rhythm as such is perceived; while motor rhythm is physiologically conditioned, its perception would involve other and conscious elements.

Ewald finds an anatomical basis for the close connection of auditory and muscular rhythm in the two functions of the labyrinth; hearing, and the keeping of the muscles of the body in tone.[1]

§ 3. The Rhythmical and Unrhythmical Subjects.

It is common to separate all persons into two classes, the rhythmical and the unrhythmical. Such a clear cut division is not warranted by the experimental facts. Numerous degrees in the perfection of the motor rhythm have been shown, as well as indications that there are the same gradations in the perception of rhythm; from that of a young child, who does not perceive rhythm except as a series of movements and these loosely connected, to the older children, whose perceptions were very complex, involving not only numerous bodily rhythms, but auditory and affective rhythms as well, all fusing to a total perception; an unitary impression arising from the manifold of sensation.

The Unrhythmical Subject. Perception of rhythm may fail because of a physiological defect, auditory or motor, or due to imperfect connection of the auditory and motor centers; or it may be psychologically conditioned. An inability to control the attention, or to compare sound with sound or movement with movement, might cause failure in perception of rhythm. Still, this does not seem to exhaust the possibilities by which failure to perceive rhythm may arise. Two boys of the upper grade, one German, the other American, were decidedly unrhythmical. By this we do not mean that they were totally unable to perceive rhythm, but that the forms which they produced lacked the unitary character and the completeness of those produced by others. Yet they were characterized by their respective teachers with the phrases "denkgründlich" and "reasons everything out." Clearly in this case perception of rhythm was not a function of general intelligence. When, however, we consider the direction of attention which has been found necessary, in order that the subjective rhythm may arise, it becomes possible to explain these cases. In the subjective grouping, there is always a surrender of the attention to the series of sounds not as separate but as successive. With these

[1] Ewald: Untersuchungen über das Endorgan der Nervus octavus: Wiesbaden, '92. Quoted by Meumann, p. 261.

boys, it is probable that the attention was not directed upon the succession of sensations but upon the reason for the experiment. Such a critical, analytical state of mind was destructive of the rhythm.

At the present time we are testing a student who shows certain abnormalities in the perception of sensory and motor rhythm. The experiments are not completed. They are (1) a test of the subject's perception of the series of auditory rhythms (the same as given to the normal subjects), upon which he reports; (2) a test of ability to tap certain required forms, the intensity and duration of which are registered by means of a transmitting tambour upon the kymograph drum; (3) a combination of the first and second tests. The subject reacts to the auditory sensations as they are given. The reaction in this case is registered upon the drum for comparison with the objective rhythm given by the disc.

§ 4. How does Perception of Rhythm differ from any other Perception of Successive Stimuli?

1. It appears to be a phenomenon characteristic of but two modalities, audition and movement. 2. The sensations must follow one another regularly and within certain time limits, the upper of which, .1 sec., is the average rhythm of the cortical cells.[1] The lower time limit for perception of rhythmic succession, 1 sec., is near the lower limit of the organic rhythms; and the most favorable rate, between .3 and .6 sec., corresponds to the natural rate of certain bodily rhythms.[2] These organic rhythms cannot be regarded as sources of the perception of rhythm; they do, however, make a fusion of the attention and organic rhythm, characteristic of the rhythmical perception, possible. 3. We compare the sensations in the series as to stress. Stress may be objectively brought about by temporal, intensive or qualitative changes,—in short by any change which marks or differentiates one member of the series from another. We judge of stress by the claim that it makes upon the attention. It may be subjectively brought about by a regularly recurring increase of attention. 4. For a comparison of two or more members of a series, it is necessary that they fall within the bounds of immediate time perception. One group corresponds to one pulse of attention, and the regularity of the subjective rhythm is due to the regularity with which the pulses of attention succeed one another. When several groups can be reproduced as a whole, they may be said to fall within the limits of immediate time perception. 5. The peculiar effectiveness of rhythmical perceptions arises from their tendency to set up sympathetic vibrations over the whole body,

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[1] Text Book of Physiology, edited by E. A. Schaefer, 1900. Vol. II, p. 708.

[2] *Op. cit.*, p. 2690.

more especially from their reinforcement by organic sensations. These sensations of like phases from the different modalities fuse to a total perception. The alternation of these perceptions we term a rhythmical perception. A perception of rhythm, then, is never a perception of successive sensations, but a perception of successive perceptions, each of which arises from a fusion or summation of sensations coming from different sense continua, but whose vibration times have like phases. 6. Because of the organic rhythms, the perception of rhythm is regarded as peculiarly subjective. We are ordinarily accustomed to refer a complex of sensations to an external object; but with rhythm the sympathetic bodily vibrations cause us to regard it as more subjective. 7. The unitary character of a rhythmical group is dependent upon its unity for perception. This is dependent upon a subordination among the parts. The greater the unity for perception, the greater is the effectiveness for reproduction. *Cf.* Hoeffding:[1] "The more gradations, the more definitely stamped features and relations a mental state exhibits, the better it can be recalled to memory." 8. The limit of the possible number of separate elements in a group is determined by the limitations of the intensive sensible discrimination. 9. Introspection does not warrant the position of two hypothetical forces, one directed forward, the other backward; or the presence of alternate feelings of strain and relief. What we do find by introspection is a constant forward direction of the attention. The apparent discontinuity in a rhythmic series is conditioned by the discontinuity in the successive acts of attention. The normal span of an attention wave varies with the unity and continuity of the object of perception. "Er steigert sich mit zunehmendem Sinn." "Continua haben ein grösseres Aufmerksamkeitsfeld als Discontinua." The attention rhythm was well characterized by a subject of Zeitler in an investigation of the range of attention.[2] "Er konnte auch Intervalle, Hebungen und Senkungen der Aufmerksamkeitswelle constatiren. Die Aufmerksamkeit 'hupfte' nach seinen Angaben über die dominirenden Buchstaben in Complexe, auf letzteren länger haftend, als auf den unbetonten Strecken. Bei grösseren Zeiten gleitet die Aufmerksamkeit ruhig über die Reihenfolge der Elemente hinweg." Rhythmical grouping may then be compared to a succession of waves. (*a*) The single group corresponds to one wave—an immediate act of attention. (*b*) The parts of a group correspond to different points in a wave; the accented tone being on the crest. (*c*) The pause is the zero

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[1] Outlines of Psy., Eng. Trans., p. 241.

[2] Tachistoskopische Versuche über das Lesen, Phil. Stud., XVI, p. 408.

point in the advancing wave. It is the time when, in the change of attention, "wir nichts in uns vorfinden," as Eberhardt[1] expresses it. 10. An analytical attention is destructive of rhythmical perception; the function of attention in the perception of rhythms is synthetical. 11. If the single impressions are separated by a greater span than that covered by one wave of attention, each impression stands alone; under regular conditions in this case primary rhythm arises. If the rate is too rapid, then there is no perception of rhythm. There is only a regular rising and falling in the intensity of what approximates a continuous sound. Bolton believes that this is because the rate is too rapid to find muscular expression. It is much more probable that perception of rhythm fails because the rate exceeds the upper limit of the cortical rhythm.

§ 5. The Influence of an Accompaniment upon Tempo.

The question of the influence of an accompaniment upon the tempo of the rhythm has been directly studied by Eberhardt (here the accompaniment was instrumental), indirectly by Miss Smith in her experiment as to the effect of rhythm upon work,—the metronome gave the time in this case,—and by Buecher. The latter, in his *Rhythmus und Arbeit*, has given a wealth of illustrative material derived from anthropological sources. He instances not only cases in which rhythm of movement is accompanied by song or instrument, but also cases in which individuals accompany each other. The present results show only the influence upon the time when individuals accompany each other.

Chorus reading. In the first experiment, immediately after the individual readings, the five members of each section were asked to give the different rhythmical forms in chorus.

In general, the time of chorus reading is longer than the average for the individual reading; but there are numerous exceptions, especially in the case of the German children, whose results at first seemed very irregular.

An accompaniment appears to have two functions: (*a*) regulative, and (*b*) excitatory. *Regulative:* when an accompaniment serves as a regulator it may either decrease or increase the normal rate. The rate of speed will be increased when the standard or leader has a rate exceeding that of the separate individuals. It will be decreased when the individuals are relatively independent of the leader, *i. e.*, when several could equally well lead. In other words, the rate is decreased in proportion to the uncertainty or irregularity of the standard. The tone of the leader, like the beat of a metronome, sets the pace.

[1] *Op. cit.*, p. 106.

TABLE LIV (*b*).
Chorus. Girls. American.

Trochee.		Iambus.		Dactyl.		Anapæst.		
Av.	Cho.	Av.	Cho.	Av.	Cho.	Av.	Cho.	
23.1	*18.16	22.3	*20.	22.4	*17.	22.	*18.	I. Class.
18.7	19.	17.5	17.	16.7	17.	20.	18.	
19.4	18.	19.9	18.	18.6	29.	19.1	19.	
17.9	18.	21.2	21.	16.9	18.5	17.2	19.	
21.	18.	20.4	21.	17.1	19.	17.8	18.5	
20.02 M.V. 1.76	18.23 M.V. .32	20.6 M.V. 1.22	19.4 M.V. 1.52	18.3 M.V. 1.76	20.1 M.V. 3.5	19.2 M.V. 1.24	18.7 M.V. .44	
23.1	26.	19.7	24.5	19.3	21.	21.3	*21.	IV. Class. ¶
19.5	‡18.	20.7	19.2	18.5	‡18.	16.5	‡16.	
16.9	17.	17.5	19.	15.2	‡14.2	14.6	16.	
14.6	18.	16.05	17.5	13.7	15.	13.8	‡13.	
15.8	16.	17.5	17.5	13.3	16.	14.1	15.	
17.9 M.V. 2.24	19. M.V. 2.6	18.23 M.V. 1.31	19.5 M.V. 1.96	16. M.V. 2.3	16.8 M.V. 2.1	16.06 M.V. 2.61	16.2 M.V. 1.3	
18.8	21.	18.8	19.	16.5	‡17.	15.5	19.	VII. Class.
19.1	20.	16.8	19.5	16.1	18.5	15.1	17.6	
18.4	18.5	18.3	19.	15.7	19.	16.	17.	
§19.	‡18.	17.5	17.5	15.5	17.	14.3	16.	
17.3	18.	17.5	18.	16.	‡15.2	15.2	17.5	
18.5 M.V. .74	19.1 M.V. 1.1	17.8 M.V. .62	18.6 M.V. .68	15.96 M.V. .24	17.3 M.V. 1.1	15.2 M.V. .42	17.4 M.V. .74	

§ Times of all individuals unusually long.
¶ Here Marjorie and Annie have much quicker time than others. Shows more in chorus.
‡ There is a lengthening of average time which brings about incongruity quite as much as the shortening of the chorus time.

tive. It holds the company to the same time and calls for an equal expenditure of energy from each of the workers. Though he gives us no data[1] as to the comparative times, we should probably find it slower than the individual times. The work for each individual is in this case increased; he must not only attend to his own, but also to his companions' tempo.

[1] Buecher does not appear to recognize the fact that the use of an accompaniment may bring about a retardation of the normal rate.

TABLE LIV (*d*).

Chorus. Girls. German.

Trochee.		Iambus.		Dactyl.		Anapæst.		
Av.	Cho.	Av.	Cho.	Av.	Cho.	Av.	Cho.	
27.26	33.	30.3	33.	27.3	‡26.	30.66	34.	I. Class.
32.7	35.	31.7	39.	29.3	33.	30.	31.2	
30.8	30.	29.6	32.	26.3	‡25.	30.	‡27.	
31.7	32.7	30.5	34.66	27.6	28.	30.22	30.7	
M.V.	M.V.	M.V.	M.V.	M.V.	M.V.	M.V.	M.V.	
2.	1.7	0.73	2.8	1.1	3.33	0.29	2.5	
22.52	24.	19.84	20.	19.3	19.	19.53	21.	IV. Class.
21.4	‡19.	20.7	‡16.	16.9	‡13.6	17.14	‡16.2	
21.2	‡19.	21.	‡17.4	17.	‡14.	17.6	‡13.	
21.7	20.6	20.51	17.8	17.7	15.5	18.09	16.7	
M.V.	M.V.	M.V.	M.V.	M.V.	M.V.	M.V.	M.V.	
0.54	2.2	0.45	1.46	1.03	2.3	0.96	2.8	
20.96	‡17.	20.62	‡16.	17.36	‡17.	16.6	‡11.	VII. Class.
18.76	‡17.	18.7	‡17.5	17.1	17.2	15.5	16.	
19.5	‡19.	18.3	‡16.	15.6	‡16.	15.9	17.	
19.74	17.6	19.2	16.5	16.68	16.7	16.	14.66	
M.V.	M.V.	M.V.	M.V.	M.V.	M.V.	M.V.	M.V.	
0.81	0.86	0.94	0.66	0.72	0.5	0.4	2.44	

was slower than her own it was faster than the natural time of the other individuals in the chorus. The results which Miss Smith[1] gives for work to the accompaniment of the metronome would fall under this head. The standard in this case had absolute regularity and stability, and served as a director of the attention; thus the majority of the subjects were enabled to accomplish more than when working alone although, as Miss Smith further remarks, the quality of the work suffered. The majority of the subjects preferred also that the metronome should give a time somewhat faster than their normal, rather than slower.

When a rhythmical accompaniment of *constant* tempo is em-

[1] *Op. cit.*, pp. 82, 94, 284, 280.

ployed to regulate a *prolonged* activity, the result is that total time taken is less than it would have been had the acti been unaccompanied. This case naturally did not arise in experiment as given here. But Buecher appears to regard it typical of the affect of the employment of an accompanime A quicker tempo, as he believes, results even when the acco paniment possesses no more regularity than that given by a low worker. "Der Einzelne lässt die Hände sinken oder v langsamt das Tempo der Bewegungen, wenn er müde wi Die gemeinsame Arbeit regt zum Wetteifer an."[1] It doubtful whether the rhythmical accompaniment would in su a case act as an excitant; and, if regulative in function, wheth the *irregular* accompaniment would not really result in slower tempo even though to the casual observer there mig be an apparent increase in rate.

Eberhardt[2] concludes that an accompaniment shortens t time, although his subjects were inclined to judge the rhyth unaccompanied as more rapid. The illusion follows naturall from the same cause as the shortened time. It is first to noted that the standard in Eberhardt's experiment possesse the requisite regularity and constancy. The attention wa directed upon the tones of the accompaniment; and the mus cian in place of making a series of time judgments attende only to the tones of the accompaniment as they succeeded on another. Eberhardt's explanation is that "der Musiker spielt ei Musikstück mit der Geschwindigkeit bei welcher die Gefühl wirkung, welche er erwartet, sich am deutlichsten einstellt; a ihr hat er einen Massstab für die Geschwindigkeit." Now he plays with an accompaniment, the feeling rises more quickly and thus less time is taken for the production of the piece. Th time taken for playing the same piece upon a silent piano still greater than that taken to play without an accom paniment. This Eberhardt explains as the result of the greate psychological activity involved and the retardation in th arousal of the feelings, in terms of which the player judges th rate of succession. But these instances seem rather to be ex amples of the increased difficulty in the estimation of tim when the number of criteria, in terms of which a judgment i made, is decreased. *The fewer the criteria and the less the constancy, the more difficult is the estimation of time and th slower the rate of succession.*

Excitatory. The chorus reading in this case was alway faster than the average time of the individuals. When all di ficulty in the production of the rhythms had disappeared, th

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[1] *Op. cit.*, p. 31.
[2] *Op. cit.*, p. 149.

children acted as a spur to each other in their reading. This was true of the German girls of the fourth grade as well as of the American classes upon occasion. The manner of reading was very different from that found in the first instance. The rhythm grew more rapid as they proceeded; there were also evident signs of extreme pleasure, and a noticeable tendency to accompany the rhythms with various movements of hands, feet, etc. It seemed to partake more of the nature of the rhythmical exercises of the primitive peoples. Buecher cites numerous cases of 'Arbeit in Wechseltakt' in which rhythm has this function. Here, he finds that the social feelings, desire to outdo one another, etc., predominate in contrast with 'Arbeit in Gleichtakt' in which the regulative function was most prominent. In these instances, in which rhythm is an excitant, the activity has become automatic and the attention can be freely directed to the pleasurable accompaniment.

CHAPTER IV. THE NATURE OF RHYTHM.

The generally accepted definitions of rhythm emphasize the affective side. Wundt[1] defines it as a complex feeling which can under certain conditions pass over into an emotion. "When the feelings produced by rhythmical impressions become more intense, as is usually the case, especially when the rhythm is connected with sensational contents that arouse the feelings greatly, they become in fact emotions." In this feeling complex Wundt distinguishes two factors, (*a*) partial feelings, and (*b*) the unitary total feeling which is a resultant of the manner of connection of partial feelings. "These partial feelings are here the feelings of strained and fulfilled expectation which in their regular alternation constitute the rhythmical time ideas themselves."[2] These feelings mediate the grouping of what would otherwise be only a series of disconnected impressions. The feeling of strain or rising expectation (both terms have been used) fills the interval between two successive auditory or tactual impressions; the feeling of fulfilled expectation or satisfaction marks the completion of the interval. Thus rhythm owes its integral nature and essential character to the interplay of these two opposed feelings.

Eberhardt[3] criticised Wundt on the ground that introspection did not reveal the presence of these two feelings. In place of fulfilled expectation he found only an absolute emptiness of content ("Bewusstseinsleere). He also objected to the term "rising" expectation; it is not happily chosen, since expecta-

[1] Outlines, Eng. Trans., p. 169.
[2] Outlines, Eng. Trans., p. 167.
[3] *Op. cit.*, p. 106.

tion, in its usual signification, is directed upon an object. But there is no such direction in the case of rhythm. If expectation is used to connote a feeling resulting from the complex made up of sensations of strain and centrally excited sensations, then the distinction between expectation and strained attention is broken down. He would therefore substitute a "feeling of attention" for the Wundtian term "rising expectation." "Die Qualitätsungleichheit wurde dann darin bestehen dass einmal ein Gefühl der Leere, wenn der Ausdruck gestattet ist, das andere Mal das Gefühl einer bis zu gewisser Spannung zunehmender Aufmerksamkeit vorhanden ist." In addition, under certain circumstances, a weak feeling of activity and of pleasantness may be found; but to these feelings Eberhardt would ascribe a very minor part.[1]

We must take exception to the terminology of Eberhardt; what he has really done is to make attention mediate the sensation. The feeling of emptiness is nothing but the period of inattention between the successive waves of attention. Why, then, is it necessary to adopt a questionable terminology to express undoubted facts of introspection? It was, probably, in order to give an explanation for what Eberhardt considered qualitatively unlike experiences, by the introduction of two qualitatively different feelings. But this is unnecessary; for the changing sensations give a sufficient explanation for whatever qualitative differerences introspection may find in the perception of rhythm. Moreover, 'feeling of attention' is scarcely a legitimate use of the term. Had Eberhardt omitted the term 'feeling' he would have given a satisfactory explanation of the facts of rhythm as introspection reveals them.

Ettlinger objects to Wundt's use of "strained and fulfilled expectation," (1) because the changing strain sensations are from their great variability an unsuitable basis for the "einheitlichen Gefühlsverlauf." (2) The "feeling of fulfillment" would not sink as suddenly as is demanded by the terms of the theory. (3) The pauses might just as well be awaited as the sounds. For these feelings Ettlinger substitutes two forces, a positive, which presses forward, and a negative, which opposes the action of the first.[2] "In der Isolirtheit und kurzen Nachdrücklichkeit der einzelnen Schläge; da diese nun aber auch die Träger des zeitlichen Zusammenhanges sind, ... bilden sie die Ansatzpunkte beider Kräfte." When we attempt to find adequate psychological terms for these two forces, it appears that Ettlinger has only thrown the familiar facts of the oscillation of attention into figurative language; what we really have

[1] *Op. cit.*, p. 106.
[2] *Op. cit.*, pp. 175 ff.

is an explanation in terms of attention. The positive force, 'fortschreitende Tendenz,' is nothing more than a direction of the attention forward. As Groos[1] says: "Die vorwärtstreibende Kraft aller rhythmischen Wiederholungen, besonders der musikalischen und poetischen Rhythmen, dieses unwiderstehliche Weiterdrangen dem wir uns so willig hingeben, ist Nichts anderes als die immer aufs Kommende gespannte Aufmerksamkeit." And the phenomena which Ettlinger explains by the action of the second force are nothing other than the objective and subjective stresses, which those sensations or perceptions receive which become the focus of attention.

Other objections might be urged against the Wundtian definition. (1) Expectation could play no part between successive impressions which follow each other at a rate which would give rise to a perception of rhythm. This objection was raised by Külpe[2] to the hypothesis that expectation and surprise mediate the estimation of short time intervals. The same objection applies here. (2) If expectation mediated the grouping, it would be hard to explain the distinction between the temporal character of the grouping produced by the younger and the older children; it would be the reverse of what it is, for the incapacity of children to sustain a long suspense would make the rhythm more rapid for the younger than for the older. As a matter of fact, the times of the younger are much slower, the intervals longer. (3) We should also expect, if expectation played any part, that the iambus and anapæst would be shorter than the trochee and dactyl. But the opposite is true. (4) The breathing curve does not show the characteristics of an expectation curve. "Bei der Erwartung, besonders wenn diese als 'gespannte' Erwartung hervortretend ist, wird eine Erhöhung der willkurlichen Innervation nebst einem Spasmus der organischen Muskeln wahrgenommen" (Lehmann).[3]

The only other recent attempt to define rhythm has been that of Miss Smith[4] who in the main follows Meumann and Wundt. She defines it as an emotion, "dessen motorischen (und damit zum Theil auch die vasomotorischen) Aeusserungen und Entladungen sich nicht vollkommen frei ergeben können, wie beim gewöhnlichen Affectverlauf, sondern dessen Ausdrucksbewegungen nach einem bestimmten Schema zeitlich und intensiv geregelt sind." While this definition does not add anything that was not implicit in the Wundtian defi-

[1] Die Spiele der Menschen, Jena, 1899, p. 183.
[2] *Op. cit.*, p. 405.
[3] Die Hauptgesetze des menschlichen Gefühlslebens, Leipzig, 1892, p. 312.
[4] *Op. cit.*, p. 291.

nition, it ignores the perceptual elements, which Wundt does not. Miss Smith goes so far as to declare that rhythm disappears when the affective tone becomes unpleasant.[1]

No explanation which makes the affective elements fundamental to rhythm can be satisfactory. (1) Introspection shows that rhythmical grouping can occur in a perfectly indifferent conscious state. This was noted by the subjects of Bolton and Smith as well as by our own. (2) Feelings become blunted by repetition. If then, rhythm originates in the partial feelings, which Wundt makes intermediaries in each and every group, we should expect a gradual weakening of the affective tone of rhythm with prolongation of rhythm; but this is not true. As a rule, the affective tone generally increases for a considerable length of time, especially when organic co-vibrations are set up. (3) The feeling, when present, does not consist of a series of contrasted feelings, such as any theory which makes feeling the intermediary of grouping must presume; on the contrary it runs a comparatively unbroken course of either gradually increasing pleasantness or, when reversed, of gradually decreasing pleasantness. The contrast brought out in grouping is ideational in source. (4) No explanation of rhythm which goes out from the feeling side can successfully explain the limitations which all groupings show (the limitations to the two and three grouping and their compounds). (5) The gradual growth of rhythmical ability and rhythmical perception can be accounted for only on the grounds of its perceptual nature. (6) The characteristics of the affective curve are not present in the rhythmic curve taken by the pneumograph. The curve, as has been shown, is that characteristic of an attentive state. (7) Furthermore, all the phenomena of rhythm can be explained by the facts of perception.

How then are we to account for the presence of feeling? For it is not to be denied that feeling is often an accompaniment of rhythmical perception. In this connection, the data which were given by the adult subjects, as to the affective tone of the rhythms given by the different discs, are interesting.

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[1] "Wenn das Gefühl, welches durch taktmäszige Bewegungen erregt wird, nicht angenehm ist, dann ist der Rhythmus (wie wir das Wort gewöhnlich verstehen) nicht vorhanden, sondern vielmehr ein Bewusstsein von Disharmonie und Unbequemlichkeit," *op. cit.*, p. 287. Introspection contradicts this statement.

Titchener (Experimental Psychology, Vol. I, Part 2, p. 353) calls attention to Meumann's evident change of view. In Meumann's own work he emphasizes the perception side of rhythm, pp. 272 f., 284, but Miss Smith, whose manner of treatment of rhythm was evidently influenced by Meumann, defines it as an emotion, as the passages above quoted show.

B. B. The regularity of the sounds is pleasant.

I. M. describes Disc 5 as pleasant and enlivening.

S. says that 7 is pleasant, reminds of dance music.

B. B., that rhythm with the forks having an interval of the minor third is pleasanter than with the former forks.

F. W. says "Disc 6 is rather pleasant; it reminds me of calling some one." Disc 9 was unpleasant.

E. P. finds Discs 1 and 7 pleasant by association with sounds of machinery. All the other discs are unpleasant. She says later: "None of the combinations are pleasant; some are even unpleasant; affection seems to have worked off from the combinations which were at first pleasant. While in the case of the combinations at first indifferent, their perception is now unpleasantly toned." With E. P. objectively conditioned rhythms are unpleasant; the pleasantness seems to be due to associations; these are more readily called up with the more flexible forms, *i. e.*, those she can herself arrange.

E. V. B. finds Disc 2 disagreeable, as some borders with straight lines. (The affective tone is here given by a visual association.) She also finds the two-group discs colorless and unpleasant by contrast with the three-group preceding. Disc 2 is pleasant, the high tone particularly so because of the singing quality. In comparing Disc 5 with Disc 1 she says: "It is much pleasanter, brighter and quicker. (1) was heavy."

Unpleasantness arises where the natural subjective grouping is obliged to overcome a strong objective rhythm. E. V. B. found Disc 8 unpleasant for this reason. (8 and 9 for all subjects were less pleasant than 6 and 7. The objective conditions were too strongly marked, there was less chance for the free play of the individual tendencies, and there were often resistances to be overcome.) For this same reason F. W. finds Disc 3 not as pleasant as 2.

The facts brought out by these replies are: (1) Feeling is not essential to the perception of rhythm. E. P., who is susceptible to all of the illusions, finds the rhythm pleasant only when associated with the familiar sounds of the factory town in which she spent her youth. How can a satisfactory æsthetic of rhythm be based of the facts of rhythmical illusion,—the supposition being that subjects susceptible to the illusion take pleasure in rhythm? This is the basal supposition of Ettlinger's whole treatment of rhythm; yet it is not warranted by introspective evidence. The illusions have their ground in the facts of sensation and perception, and not in those of affection. (2) Pleasantness is very frequently of an associative character. (3) In instances where the pleasantness seemed to attach to the rhythm per se, the three-group was said to be pleasanter than the two-group because it was 'richer,' 'brighter.' Those succeeding each other quite rapidly were pleasanter than those having a slower rate. Regularity of sound was found to be pleasant. These instances can all be subsumed under the rule that a rhythm which is moderately stimulating is pleasant. (4) In the same connection it is interesting to note what forms were found to be especially unpleasant. These were Discs 8, 9, 3 and 4. Here the objective conditions of the rhythms are very

is too complex to be readily perceived, unpleasantness may also attach to it. The demand made upon the cortex in such a case exceeds its normal capacity for function. Of the same nature is the unpleasantness which arises when an objective rhythm through the lengthening of one tone and accenting of another disturbs the normal activity.

The æsthetic effect of the rhythm is not due, as Wundt remarks, to a summation of the sense feelings, but arises from the manner of connection of these sensations. One arrangement of intensities is pleasanter than another because it increases the unitariness of the total impression and its efficacy for reproduction.[1] The various possible arrangements of the objective factors, temporal, intensive and qualitative, have a greater or less æsthetic value according to the approximation of the resultant impression to a unitary character. Here is another instance of a pleasantness arising from the perception of unity in the manifold. It is doubtful, however, if the pleasantness which children find in rhythm is ever of this type. Generally, they had no preferences as to arrangements. When a truthful report upon the pleasantness of the different rhythms was given, the trochee was commonly preferred because it was easier to get. This was clearly not an æsthetic judgment. The pleasantness of the rhythm arose for them, undoubtedly, from resulting bodily activities.

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[1] *Cf.* Külpe's treatment of æsthetic feeling, Grundriss, p. 264.

trical contact in connection with the release key of the longer pendulum, which greatly increases the variety of stimuli that can be used with it. These changes have involved a considerable remodeling of the instrument.

Adjustment of the Bobs. It will be noticed in the accompanying cut of Model I that both bobs and the supporting post at their right are pierced with sizable holes. The upper one of the holes in the post is bored at such a point that when a close fitting rod is slipped through it and through the hole in the bob of the short pendulum the latter will have its proper distance from the edge of the bar from which the pendulums hang. The lower hole is similarly placed with reference to the bob of the long pendulum.

To hang the bobs at their proper distance all that is necessary is to slip the rod through the appropriate hole in the post, slide on one of the bobs till it reaches its proper position, pass the thread twice through the small hole in the bob, draw the threads straight and withdraw the rod.[1]

Keys and Releasing Apparatus. The improvements in this part of the apparatus consist in bringing the keys much nearer the base and in making them more solid. The need of vertical adjustment has been obviated by careful construction. The links, which in the old form of the instrument were separate and liable to be lost, are now permanently attached to the bobs. Among minor points of improvement may be mentioned the increased weight and larger surface of the base, the better shape of the bobs and supporting bar, a simplified means of fastening the threads, the placing of the holder for the stimulus card on the bar from which the pendulums hang,[2] and the attachment of the screen holder to the operator's key by a socket and set-screw.

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[1] If the setting of the bobs is to be the same from time to time it is necessary of course that the threads be drawn up each time with the same degree of tension. It is clear also that any error in the position of the holes in the post and any looseness of the rod in the holes will affect the length of the pendulums, though when the threads are drawn tight the latter is not important. The holes, however, are placed with care and the errors arising from this source are small, and perhaps for practice work might be wholly neglected. Where more exact results are desired the swings may be counted and the pendulums adjusted by count, or an arithmetical correction applied as explained in the *American Journal of Psychology*, Vol. IX, p. 194, and in Titchener's Experimental Psychology (Instructor's Manual), p. 213.

[2] This improvement, which has been used in a considerable number of instruments of the old model, was suggested by Miss Hattie E. Hunt, late of the Rhode Island State Normal School, Providence.

MODEL II.

Fig. 2.

The instrument in the form just described has a tolerably wide field of usefulness, as may be seen by consulting the original description in this *Journal* or Titchener's Primer of Psychology, pp. 182 ff. It does not, however, lend itself easily to experiments requiring the discrimination of two stimuli and the choice of a reaction appropriate to one or the other, nor does it allow the taking of simple reactions with stimuli of variable character, intensity or place, nor, in a very satisfactory way, of those with visual and electrical stimulation. These are all made possible by the addition of a second key to the releasing apparatus of the shorter pendulum and of electrical contacts to the release key of the longer pendulum. The instrument in this form is shown in Fig. 2. The pendulums, supporting bar and post are like those of Model I, and the base differs only in being about an inch wider. The new release mechanism made necessary by the doubling of the short pendulum key (and used in this instrument for the long pendulum also) will be readily understood from Fig. 3, which shows it in section as used for the latter.

The link of the pendulum is held between a sloping boss and

the conically hollowed head of a plunger, the plunger being kept down by a spring. When the key is pressed the plunger is raised and the link released. The mechanism is the same in the case of the short pendulum, except that the ends of both keys come under the foot of the plunger, so that if either is pressed the plunger is raised and the pendulum released.

The electrical contact fitted to the operator's key is of very simple construction. One contact surface is placed on a spring on the upper side of the key and the other on the point of a

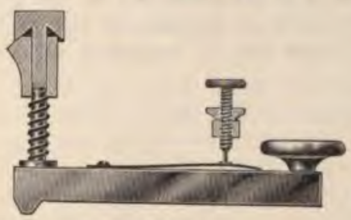

Fig. 3.

screw above it. The lower contact is placed on a spring in order to insure good electrical connection without interfering with the grip of the plunger on the link of the pendulum. The electrical circuit leads through the spring, the body of the key and the base to a binding post attached to the latter. The upper contact is of course connected with a binding post which is insulated from the base. By means of these binding posts the operator's key may be brought into the primary circuit of an induction coil, which on the depression of the key will be broken at the same instant that the long pendulum is released. By the use of the induction coil thus introduced are made possible the various forms of experiment mentioned above. When, for example, the secondary terminals of the coil are connected with a Geissler tube, the apparatus can be used for simple reactions to visual stimuli; when connected with suitable electrodes, for reactions to electrical stimulation of the skin; and when connected with a telephone, for auditory stimuli of a very convenient kind. If the induction coil is of the sliding pattern common in physiological laboratories, stimuli of varying intensity of any one of these sorts can be given by changing the distance of the secondary coil from the primary. Stimuli in variable place can of course be obtained by putting in several Geissler tubes, pairs of electrodes, or telephones in parallel circuit, and using one or another without the previous knowledge of the subject.

The change in the releasing mechanism necessitated a change in the clips for holding the stimulus card and the screen. The

former is placed on a short post on the base near the left of the operator's key, and the latter is attached to a cam or opposite side, which is turned by the depression of the These clips are shown without the card and screen in the eral view, Fig. 2.

With an instrument of this pattern all the more impor experiments upon the time relations of mental phenomen possible, except those requiring the exact measurement of time elapsing between a spoken stimulus word and a sp reply by the subject; and even here, with a little practice operator can learn to depress his key at the giving of the s lus word (and the subject his key at the giving of his re with ample exactness for all purposes of demonstration even of research.

FLUCTUATION OF THE ATTENTION TO MUSICAL TONES.

By E. B. TITCHENER.

Dr. Heinrich found, in 1898, that minimal tones do not fluctuate ("dass bei Tönen keine Intensitätsschwankungen zu beobachten waren:" see this *Journal*, October, 1899, XI, 119). The tones employed were the high tones of a Galton whistle, and tones from the middle and lower regions of the scale given by organ pipes and wide glass tubes.

In 1899, H. O. Cook, working under my direction, found that fluctuation occurred with the Politzer acoumeter (c^2), with an electro-magnetic fork of 512 vs., and with a blown bottle whose tone was approximately that of 256 vs. (*ibid.*, 123).

Dr. Heinrich replied in 1900 (see this *Journal*, April, 1900, XI, 436) that Cook's fluctuations were due to "bruits à peine perceptibles." He also published the results of experiments on perfectly pure tones (the tones of singing flames, placed under certain physical controls), which showed no fluctuation.

We obtained a gas harmonica from Kohl, and standardised the two lower tones as Dr. Heinrich prescribed. The experiments were made under my direct supervision: experimenter, Miss J. A. Cochran, a graduate student in the Psychological Department; observers, Mr. J. D. Speer and Miss E. Parry. Of these, J. D. S. had had special practice with minimal stimuli, and had observed their fluctuation, in various sense departments; E. P. had had only general practice in introspection. Ten series of observations were taken from each observer. *There was no fluctuation.*

I regret that the experiments could not be carried farther. But it is only fair to Dr. Heinrich to publish this confirmation of his statement. The fact (if it prove to be a fact, on farther test) is one of high theoretical importance. The fluctuations have been proved to be independent of peripheral conditions, *e. g.*, in the case of sight; and I am no more able than is Dr. Heinrich to offer an explanation of their absence in the case of pure tones.

tive analyses. Nevertheless, chemistry at least has found the distinction of large practical utility and there is at the outset, therefore, some presumptive evidence from analogy in favor of the incorporation into psychological methods of this differentiation. As applied to psychology the distinction clearly involves the mere question of the specific focus of interest. Are you concerned primarily with the problem of the constitution of a mental complex and its analysis into the several component factors, then your method is essentially qualitative. You cannot in such a method disregard quantitative elements. Indeed, you must employ them as parts of your technique. But your interest is not centered upon them as the end of your inquiry. Conversely, a quantitative analysis must involve qualitative differences brought out in the course of investigation, but in this case they fall into the background as of secondary importance.

Whether in actual practice it is not economical of time and effort to work over a given field, *e. g.*, that of dermal sensations, by intermingling quantitative and qualitative experiments, rather than to follow out the complete series of qualitative observations first, is a matter which can be decided only in the light of experience and the exigencies of local conditions. Numerous considerations, both pro and con, will at once suggest themselves. But despite Mr. Titchener's obvious opinion, there seems to be no reason why, after the appearance of the Manual on quantitative work, an instructor should not combine the two in any way he chooses. It may be, that when this second volume appears, the author will assign quantitative investigations a position in the hierarchy of psychological methods, which will still further fortify the wisdom of his division.

It has been a source of the utmost gratification to the reviewer to note the author's repeated emphasis upon the fundamental importance of qualitative analyses. The present writer has long felt that the somewhat morbid ambition of many of our most energetic experimentalists to present the facts of psychology in the purely quantitative formulæ of physics and mathematics was retrogressive and harmful in its influence. It is not that quantitative considerations have not an important place in experimental methods. On the contrary, this is stoutly maintained. But they must always be ultimately subservient to the interests of qualitative analyses, otherwise we have no longer psychology, the science which investigates the structure and function of mind, but mathematics—or physics—indulging herself in a new field. When a student, who is temperamentally a physicist or a mathematician, strays into psychology, it should cause no surprise to find his perspective somewhat distorted, much less to find him at times confusing means and end. But it certainly does furnish adequate ground for frequent and, if necessary, vociferous insistence on the proper position of quantitative methods.

In the general form and construction of his book Mr. Titchener has consulted the best precedents of the laboratory manuals in other sciences. The student's part contains in the case of each experiment a succinct and lucid statement of the purpose of the experiment, a list of the materials necessary, with explicit dimensions, and definite instructions for the mode of procedure and the tabulation of results. Suggestive questions at the end of the directions invite the student to emphasize the most significant portions of his observations, to connect them with that which he has previously learned, and to go on beyond the limits of the original problem to further questions of cognate character. Cuts, diagrams and illustrative tables are liberally provided.

In the older sciences the question might be raised concerning the necessity for an instructor's manual. But in the present condition of

his judgment and experience to the severest test. He will not look for unqualified endorsement of this part of his work from his fellow craftsmen, for it is altogether improbable that any two experimentalists would agree upon an identical series. He will have scored a notable success if he escape the charges of omitting some essential features and incorporating some ambiguous, inaccurate experimentation. Although the reviewer proposes in a moment to have his little fling at Mr. Titchener, he cannot conscientiously lay either of the above complaints at his door. Taken as a whole the experiments serve admirably to convey not only a substantial knowledge of the basal facts concerning the several processes of fundamental psychological import, but also a trustworthy impression of the scope and technique of the more significant experimental methods employed for the qualitative analysis of consciousness.

As suggestive of the variants which would commend themselves to the reviewer, the following may be mentioned. One or two experiments upon the æsthetic preferences among simple line figures might be added. These experiments are not difficult to arrange in a manner sufficiently accurate greatly to assist the analysis of elementary æsthetic processes. They can readily be made to furnish a highly valuable basis of a concrete kind for an intelligent apprehension of the æsthetic categories of symmetry, proportion, etc. In view of the constant necessity for precautions against fatigue, it seems judicious to have at least one experiment in which the progressive stages of mental fatigue are themselves the subject of observation. Certain of Binet's computation methods are readily available for this purpose and they are at least sufficiently representative to be of real value in such a course. More important, perhaps, than either of these experiments is the experiment involving the comparison of visual and tactual space. Space is so conspicuously unhomogeneous in its psychological characteristics, and our comparative judgments are so evidently developed achievements involving complex experiences, that this experiment is of great significance as a ready and conclusive mode of furnishing relatively precise impressions of certain of the sensory interrelations concerned. The extremely easy test upon the so-called size-weight illusion possesses a somewhat similar value. It is of course understood that, alongside of considerations of intrinsic value, one has in selecting one's experiments to take account of available time. The above suggestions may serve to illustrate, however, the comment made a few lines above, that every laboratory man would have his own pets, which he would in some cases possibly prefer to Mr. Titchener's recommendations.

The one point where the reviewer feels disposed to take serious issue with Mr. Titchener concerns his treatment of the physiological expressions of the affective processes. This is an issue of fact and Mr. Titchener undoubtedly is convinced of the reliability of his observations. Certainly he couches his directions and specifications so that—to mention only a single instance—one must gather that one has made a faulty experiment, if one fails to secure dilatation of the blood vessels of the hand and arm, when supposedly experiencing pleasure. On this subject the reviewer is undoubtedly partisan and therefore a critic open to just suspicion. But he feels that the body of evidence presented in recent years by the laboratories of the Sorbonne and the University of Chicago, without mentioning many other trustworthy observations, is sufficient to warrant a more conservative attitude than the one adopted. In the case of the theories of reaction, for example, Mr. Titchener, who has in this field been a vigorous protagonist, makes a presentation which is altogether unprejudicial to the interests of the

different views maintained by experimentalists. In the present case of the affective processes our criticism does not touch his right of adherence to the older doctrine, but rather the mode of presentation, which in our opinion is distinctly indicative of finality, where finality is quite open to question. With Mr. Titchener's view of the relation of affection to attention and the conspicuous place which attention occupies in the experimentation above referred to, the nexus between the older and the newer formulations is by no means difficult to establish. We regret, therefore, that the author has not phrased this part of his work more flexibly. In a similar manner the reviewer is quite confident that the statements based on the dynamometrical experiments are too extreme. A full discussion of these points is, however, obviously out of place here.

Despite the conventional unpopularity of comparison, Mr. Titchener's book will inevitably be compared with Mr. Sanford's Manual, which has hitherto occupied the field alone. A word of comment on the two books may, therefore, be permitted. In the reviewer's opinion the books so far from becoming competitors are likely to be felt as indispensable supplements to one another. There can be no possible question that Mr. Titchener's volumes supply a long felt need, which Mr. Sanford's book largely failed to satisfy. We have already pointed out some of these particulars. But Mr. Sanford's book has been of invaluable assistance to every laboratory in this country, and its wealth of experiments and its convenient bibliographical materials will retain for it a necessary place in every laboratory course. With two such books at his side it must be an ill-trained and incompetent instructor who cannot make his introductory experimental work effective and interesting.

Mr. Titchener's publishers have given his books a most attractive dress. The typographical work is beyond criticism. Carefully prepared indices, lists of apparatus, etc., complete the highly efficient system of devices for rendering the material of the volumes easily accessible.

JAMES ROWLAND ANGELL.

The University of Chicago.

The origins of Art—a psychological and sociological inquiry, by YRJÖ HIRN. Macmillan & Co., 1900.

In this carefully written volume of 300 pages Prof. Hirn has given us, not only an able discussion of most of the current questions of æsthetic theory, but has so balanced certain features of explanation that the result becomes original if not completely just. Art is represented as arising from a feeling-state or emotion, in which is contained the desire not only for exteriorization but for social transmission. In this latter process secondary qualities arise which aid in securing the transmission and perpetuation of the original feeling-state. These have been derived from the media, which, moreover, were originally called into being by utilitarian non-æsthetic needs. These media are not merely to be regarded as the material, the clay, the gesture, the mark, the sound, the bright or attractive object, but the purposes already in existence before the art-impulse uses them for its higher needs. These are also origins, among which Prof. Hirn discusses in detail (1) the need for conveying information, which in an art form is retained as lucidity; (2) the need for erotic propitiation, or more generally for obtaining favor, recognized in the sensuous and attractive forms of art; (3) the need of co-ordination in work or war, retained as stimulation or excitement; and (4) the faith in magic, giving us the most characteristic quality of imagination.

As will be seen, this is a scheme which fits in most admirably to the

exigencies of research. These four sub-heads really classify different explanations that have been offered of art phenomena, and thus form excellent divisions by which the literature of the subject may be conveniently treated. The book bears the imprint of the serious scholar not only in its immediate contents but in the very complete references and indices which are appended.

It is to be regretted, however, that a writer so subtle and discriminating as Prof. Hirn has seemingly never deliberately placed before him the chief aim of the modern psychologist in all matters of origin. This we might say is not so much to analyze correctly the conscious processes, introspectively, experimentally or anthropologically, and to assume the beginning of these processes as to any extent original; but, taking such an analysis as a starting-point, both to enquire what light it throws upon processes, no doubt partially represented although not consciously related, and to discover how these partially represented processes affect the analytic starting point. Consciousness thus becomes something like a tool with which we essay to unearth the buried tree of phylogenetic mental life, a tool, however, made from this very tree itself.

Retaining a firm hold upon this genetic point of view, we may readily admit, with Prof. Hirn, that the already evolved or present art impulse may use and transpose purposes of magic, purposes of erotic propitiation, etc., without denying that possibly one or other of these motives, or rather what lies back of them, may not have created the art-impulse itself. To illustrate by an analogy the mud wasp does not build its cell, fill it with spiders alive but numb, and lay its eggs for any conscious reproductive purpose, but it is yet the reproductive instinct which leads to, and creates, or is the deepest origin of the acts in question. The appeal to consciousness, although in one sense ultimate, must be interpreted much more broadly and genetically than is apparent in the book before us. When one looks for ultimate origin he looks for something deeper than individual or social purpose.

In the view of the present writer, Prof. Hirn is never stronger than at the start. All the facts of recent research converge to render unassailable his claim against the intellectualist and in favor of the emotionalistic interpretation of art. But in showing what is contained in the art feeling-state or emotion, Prof. Hirn unfortunately deserts his original position and continually offers conscious intellectual purposes as the essential content of his explanations. This is shown in his first step introducing the social factor where he makes it an essential feature of the art-impulse that it should convey the feeling-state to others. To convey not only art feelings but every kind of feeling and thought to others is no doubt essential to normal human beings, but there is no proof that this decidedly not autoteleological purpose makes any particular art production either more or less artistic. When an artist consciously tries to shape his product so that it may be acceptable to others he may as frequently be destroying its real artistic quality as not. In the same way it is no doubt true that the art impulse tends to enhance or relieve an emotional state, and Prof. Hirn is particularly excellent in his analysis of these effects, but there is no proof that this conscious purpose is to be looked upon as their origin, or indeed as always favoring their manifestations.

An illustration will make this plainer and also bring to light a feature of the art psychosis neglected by Prof. Hirn. Pres. G. Stanley Hall in his study on Children's Fears gives the case of little girl who on going to bed imagined the room tenanted by crawling shapes of every kind. After enduring this for many nights she came to imagine the four big lions stalked into the room and took up their positions as

defenders at the four corners of the bed. At this point the little girl fell peacefully asleep.

These few events have all the essentials of a little drama, but without desire to communicate it to others, nor was there any conscious purpose to relieve the state of mind. The conscious efforts had no doubt been already tried and found ineffectual, and that partly because they were conscious or known to be intended. It is only when the lions stalk in of themselves that the imagery becomes a drama or a real art product.

It is this completion of a train of feeling with its images in such a way as to become satisfactory but without depending on outside help, that is the essential feature of the art psychosis neglected by Prof. Hirn, and which accounts not only for such stories as Red Riding Hood, but modern novels where the authors report that these characters seem to them to have a life of their own which they feel forced to obey and follow in their delineations. This is manifest in music and dancing, but also in the graphic forms where, for example, as in painting, the picture as it becomes artistic and not a mere photograph, asserts itself as the meaning of the objects portrayed, which latter are changed, augmented, decreased, selected or emphasized, so that the picture recalls nature, but also completes or adds to it, much in the same way as the lions and their emotional accompaniments, stalked into the scene of the little girl and made it a satisfactory play.

With this difference in the analysis of the essential feature of the art psychosis it is easier to see the possibility of the completed Art state or emotion being derived from a deeper lying emotion or state which has so combined with the other contents as to transform or complete them. In the case of the little girl, it was a sthenic emotion of some kind which came in, accompanied by, either slightly before or slightly after, the entry of the lions. The question for the psychologist is, what is the original phylogenetic form of this sthenic emotion? That it was an emotion not so much of self-confidence, but of love and reliance on another, with a characteristically feminine sense of protection is an indication. All the better for the phylogenetic interpretation that it occurs in a case, where any conscious sexual purpose or feeling must be absent. Indeed Prof. Hirn's assumption that the phrase "erotic propitiation" describes the theory of the sexual origin of art, rather than narrows it, and perhaps degrades it, is of itself sufficient to blind him to the real value of the theory, for further appreciation of which the reader may be referred to the present writer's article in Vol VII of this *Journal*. COLIN A. SCOTT.

Sowremmennaja experimentalnaja psychslogija w jejr otnoshenii k woprossam schkolnago obouchenija. [Modern experimental psychology in relation to questions of school instruction.] By ALEXANDER NETSCHAJEFF. St. Petersburg, 1901. pp. 236, with 79 tables.

The species of psychological pessimism "made in Germany," which Münsterberg has been endeavoring with so much ardor to introduce into America, has apparently not infected Russia. Dr. Netschajeff's book is a strong earnest plea for the application of experimental psychology to education and a refutation of the dogma that this new science is not of direct value to the teacher. He admits that the teacher need not necessarily be an experimenter herself; but that she must be familiar with the results of experimental psychology; and he believes that these results are easiest comprehended when one knows the methods and steps by which they have been reached.

The first chapter discusses the adaptation of the school programme to age and mental capacities of children. The author cites from Gilbert's studies made at New Haven facts which tell strongly against

rigid uniformity. The second chapter discusses the school day with special reference to the effects of mental fatigue. He very clearly shows that the best intellectual work can be done only when frequent rest pauses are taken. Recesses must therefore be provided with sufficient frequency to afford opportunities for recuperation. In no sense can gymnastics take the place of the free spontaneous exercises which the recess affords. Indeed, the author is very pronounced in his opposition to gymnastics—at least as required in the Russian schools. They are stiff and mechanical and military, he affirms, and are heartily hated by the children. In the third chapter he discusses some of the factors involved in healthy mental development. With young children objective methods are strongly commended. The fourth and fifth chapters discuss various problems of school instruction—means of training the memory, uses of oral reading, acquisition of skill in mechanical exercises, etc.

The style of the book is clear and simple as it is intended for the use of Russian teachers. All the author's statements are well supported with facts from experimental psychology, and his familiarity with a wide range of investigations made in Germany, France, and America is quite remarkable. One finds frequent citations in his book of the excellent investigations made at Clark University, Yale University and other seats of learning in the United States where the value of psychology for teachers is illustrated and emphasized.

WILL S. MONROE.

Hypnotism and Suggestion in Therapeutics, Education, and Reform, by R. OSGOOD MASON. Henry Holt and Co., New York, 1901. pp. 344.

The chapters here are the subjective element in the newer therapeutics, the relation of hypnotism to the subconscious mind, cases in general practice treated by hypnotism and suggestion, educational uses of hypnotism, forms of suggestion useful in the treatment of inebriety, six cases treated by hypnotism without suggestion, and the ethics of hypnotism.

Mental Wandering, by WILLIAM JULIUS MICKLE. *Brain*, Part 1, 1901. pp. 26.

The distinctive features of this paper deal with partial or complete transient division of self consciousness in mild, quiet delirium, attempts to analyze phantasmal experiences; the metamorphosing effects of sleep dream; and the lively emotion of play in mental wandering.

Studien über die Narkose zugleich ein Beitrag zur allgemeinen Pharmakologie, von E. OVERTON. Gustav Fischer, Jena, 1901. pp. 195.

After a general part characterizing anæsthetics and the various methods, the writer discusses the chief hypotheses on the mechanics of narcosis. In the special part, which follows, the narcosis of ether and chloroform are treated in great detail.

Les grands Symptômes Neurasthéniques (Pathogénie et Traitement), par MAURICE DE FLEURY. F. Alcan, Paris, 1901. pp. 412.

The sensation of fatigue, the condition of the circulatory apparatus in neurasthenics, troubles with sleep, digestion, excretion, the genital system and the mind, are the captions under which the writer gives us an interesting and comprehensive survey with suggestive tables and charts.

L'Opinion et la Foule, par G. TARDE. F. Alcan, Paris, 1901. pp. 226.

The relations of the crowd to opinion and the way in which they influence it are here made the subject of a very interesting memoir. The data are gathered not only from normal, but from criminal groups, and we have here interesting contributions also the psychology of conversation.

Eaglehawk and Crow. A Study of the Australian Aborigines, by JOHN MATHEW. New Amsterdam Book Co., New York, 1900. pp. 288.

The writer's novel views upon the anthropology of Australia are essentially that the language of the extinct Tasmanians was the substratum of the Australian languages; that they were the first occupants of the country; that it was settled not from the northwest, as Eyer had urged, but from the northeast; that the amalgamation of the two races offered an explanation of the existence of two primary exogamous classes through the greater part of Australia. The work is largely linguistic and abounds in tables and vocabularies.

Races and Peoples. Lectures on the Science of Ethnography, by DANIEL G. BRINTON. David McKay, Philadelphia, 1901. pp. 313.

The physical elements of ethnography; the psychical elements of ethnography; the beginnings and subdivisions of races; the Eurafrican race, including the Hamitic, Semitic, Euskaric, Aryac and Caucasic stocks, are treated in the first five lectures. Then follow the Austafrican, including the Negrillos, Negroes and Negroids; and

Kant contra Haeckel, von ERICH ADICKES. Reuther und Reichard, Berlin, 1901. pp. 129.

The thesis here is that Haeckel's view of the world is not monism, but materialism. The latter is refuted. True monism is described as at once probable, yet incredible. The conceptions of a world riddle is described as one of the signs of our times.

Ideen zur Philosophie der Geschichte der Philosophie, von MORITZ V. STRASZEWSKI. Wilhelm Braumüller, Wien, 1900. pp. 50.

The writer praises as the three chief ends of philosophy the deepening of the religious life, the unitary presentation of the spiritual content of our time, and the distinction between the appearances and the facts of knowledge.

The Philosophy of History, by S. S. HEBBERD. Published by the Author, La Crosse, Wis., 1901. pp. 311.

The chapters here are the nature of thought, the civilization of India, classical and mediæval civilization, the reformation and the genesis of science, modern art and morality, social revolutions since the reformation. The author's studies have been careful and extensive, and his work is an admirable and original treatment, which merits a far better dress.

The Life of the Bee, by MAURICE MAETERLINCK. Translated by Alfred Sutro. Dodd, Mead and Co., New York, 1901. pp. 427.

This is an admirably told story of the swarm, the young queen, the nuptial flight, the massacre of the males, the progress of the race, etc. The writer has carefully utilized the standard authorities.

The Limits of Evolution and Other Essays Illustrating the Metaphysical Theory of Personal Idealism, by G. H. HOWISON. The Macmillan Co., New York, 1901. pp. 396.

The most remarkable thing about this able and remarkable book is its attempt to vindicate the standpoint that all existence is either the existence of minds or that of the items and order of their experiences; that time and space owe their entire existence to the relations of minds, the co-existence of which is not temporal or spatial. These many minds may by an ancient metaphor be called the city of God. God is their fulfilled type, the bond of their union, reigning in them by light, reason and final causation. These minds are members of an eternal republic with no origin but a purely logical one and free of and controlling the natural world. They constitute the whole world of spirits, including God, united through recognition of him; and thus they are the real prime mover toward the goal of a common ideal, now called evolution. As the mind's creation simply means the eternal fact that God is a complete moral agent, and such dependence on him that if he did not exist they would not, because raised to reality in and through his existence.

This new monadology with its able and ingenuous supplements is most opportune in this day when epistemology has resolved the soul into an accidental drifting together of essentially unconnected psychic states. It will strike many as a hazardous step, but it is certain no more so than the desperateness of the situation justified. To have thus turned the instinctive longing for immortality, which is a passion with many minds as it was with the late F. W. H. Meyer toward such an hypothesis, though it be but as a protest to the morselizationists, is not only a clever strategic move, if one wished to regard it from a merely controversial standpoint, but Professor Howison's hypothesis is in the line of most of the earlier psychological thinking of the

world, and squares with one of man's deepest instincts. Demonstrable it is not any more than is the post-mortem existence of souls after death as assumed by the telepathists, but its argumentation is far above and has nothing to do with theirs.

The Lesson of the Life of Huxley, by WILLIAM K. BROOKS. From the Smithsonian Report for 1900, pp. 701-711. Govt. Print, Washington, 1901.

These few pages are perhaps the most interesting and suggestive that have been or even could be written on its subject by our leading American biological thinker, who can appreciate and judge not only the technical but the philosophical work of Huxley.

Dragons of the Air, by H. G. SEELEY. D. Appleton and Co., New York, 1901. pp. 239.

This account of extinct flying reptiles, with 80 illustrations, is by a thorough master of his subject, who has worked it over in lectures at the Royal Institution.

Outlines of general Biology, by CHARLES W. HARGITT. C. W. Bardeen, Syracuse, N. Y., 1901. pp. 164.

After ten years experiment with this new departure from the old verification methods, this work takes up the frog and fern, and then considers the animal and vegetable cell, and selects as types the hydra, medusa, fungi, earthworm, starfish, sea urchin, clam, crayfish, grasshopper, liverwort, moss and flowering plant.

Aether und Wille oder Haeckel und Schopenhauer, von RICHARD WAGNER. Hermann Seemann Nachfolger, Leipzig, 1901. pp. 238.

We have here eleven somewhat rambling but not uninteresting discussions of Haeckel, Schopenhauer, cause, space, time, genius, etc. On the whole it is an interesting, but not very luminous or novel volume.

Energismus, von JOSEF SCHLESINGER. Karl Siegismund, Berlin, 1901. pp. 554.

This is the doctrine of the absolute resting but substantial existence of the general space of worlds and its effective and creative power in an attempt to build up an anti-materialistic natural science. The author is a Professor in the Agricultural School at Jena, and develops his views in forty discourses.

The Octocyst of Decapod Crustacea : Its Structure, Development, and Functions, by C. W. PRENTISS. From the Bull. of the Mus. of Comp. Zoölogy, Vol. XXXVI, No. 7. Cambridge, Mass., 1901. pp. 251, with 10 plates.

Revision of the Skunks of the Genus Chincha, by ARTHUR H. HOWELL. North American Fauna, Aug., 1901, No. 20. Govt. Print, Washington, 1901. pp. 47, with plates.

The Commonwealth of Cells. Some Popular Essays on Human Physiology, by H. G. F. SPURRELL. Baillière, Tindall and Cox, London, 1901. pp. 115.

This booklet describes living matter, the chemistry of the body, its mechanics and physics, the nervous system, and the body generally, in five popular essays with two or three score of rough illustrations.

The Protozoa, by GARY N. CALKINS. The Macmillan Co., New York, 1901. pp. 347.

This is a summary adapted to the needs of both general and special

students of biology. Its subject matter is treated from the historical, comparative, and general point of view. Its index and bibliography, the latter of which is up to date, greatly increase its value.

Dictionary of Philosophy and Psychology, edited by James Mark Baldwin. Vol. I, pp. 644. The Macmillan Co., New York, 1901.

This is the first volume of a long expected, needed, and comprehensive work. It includes many of the principal conceptions of ethics, logic, æsthetics, philosophy of religion, mental pathology, anthropology, biology, neurology, physiology, economics, political and social philosophy, philology, physical science, and education, and gives a terminology in English, French, German and Italian. We withhold final review until the appearance of the other two volumes. Suffice it to say here, that it promises to be a work entirely indispensable to every pupil and student of the subject.

A Manual of Psychology, by G. F. STOUT. Hinds and Noble, New York, 1899. pp. 643.

This work claims to be from a genetic point of view and illustrates the earlier stages by reference to the mental life of animals and the conditions of lower races; but it should be distinctly said that it is essentially the stock subject matter of psychology, and is genetic in hardly any sense except that it places sensation first, and passes on to perception, conception, etc.

New Psychology, by J. P. GORDY. Hinds and Noble, New York, 1900. pp. 402. Price, $1.00.

This primer, which has now reached its seventh edition, recognizes the newer departments of child study, brain and nerve, Herbartian interest and apperception, and is designed for progressive young teachers, who have not been to college. Questions are appended to all its brief forty-two chapters.

Die Element der Psychologie, von H. DE RAAF. H. Beyer und Söhne, Langensalza, 1901. pp. 132.

The formation of concepts, their movement, thinking and understanding, logical, æsthetic, moral, and religious consciousness, and finally self-consciousness, are the subjects treated.

Contributions to a Psychological Theory of Music, by MAX MEYER, University of Missouri Studies, June, 1901, Vol. I, pp. 80. Price, 75 cents.

Professor Meyer, formerly Wundt's assistant, is one of the best living authorities on the psychology of music from the physicist's standpoint. He is certainly now our American authority, and his years of careful experimentation, first at Clark and for a year in Missouri, have distinctly enlarged our knowledge of this subject and resulted in important corrections of the views of Helmholtz and other previous writers. In this valuable paper, Dr. Meyer first discusses the æsthetic laws of melody, containing only two different notes, and then the complete musical scale. This is followed by an analysis of thirteen complex melodies; *i. e.*, of melodies not related directly to each other, so that it must be theoretically dissolved into partial melodies. Most interesting are the fourth, fifth and sixth chapters on the psychological laws effective in the historical development of melody; on the theory of melody; and the æsthetic laws of harmony.

Proceedings of the Society for Psychical Research. Oct., 1901, Vol. XVI, Part XLI. Kegan Paul, Trench, Trübner and Co., London, 1901. pp. 649.

Here at last we have Professor J. H. Hyslop's study with Mrs. Piper of the problem of personal identity. The author throws out the question of the supernormal and of spiritualism generally. Spiritism as an alternative explanation to telepathy, we are told, is nothing more than the question whether the brain of the medium is adequate to account for the facts. During his entire work Professor Hyslop has not remarked "one single suspicious circumstance." The last half of the volume is an appendix of four sittings, with notes. We hope to give a fuller review of this study later.

The Practical Secrets of the New Psychology and Mind vs. Medicine in the Treatment of Disease, by J. SAM JONES. Harrison, Ark. pp. 136.

These precious pages of this little $5 pamphlet must not be measured solely by the value of their scientific message to a world lying in ignorance of soul secrets, but also by their power, when rightly applied, to treat, if not cure, all diseases. Appendicitis, bashfulness, corns, business success, control of children, deafness, fits, freckles, "la grippe," love making, nervousness, paralysis, pimples, piles, stammering, sleeplessness, the tobacco habit, whiskey habit, warts, etc., may all be affected, if not cured, by the new psychology here taught.

Studies on the Effects of Electricity on Organisms. II. The Reactions of Hydra to the Constant Current, by RAYMOND PEARL. Reprinted from the Amer. Jour. of Physiology, Vol. V, June, 1901, pp. 301-320.

Der Ursprung der Sprache, von F. LÜTGENAU. Hermann Seemann, Leipzig, 1901. pp. 32.

Experimentell-Psychologische Untersuchungen über das Urteil, von K. MARBE. W. Engelmann, Leipzig, 1901. pp. 103.

De l'influence de l'esprit sur le corps, par DR. DUBOIS. Schmid and Francke, Berne, 1901. pp. 92.

Ueber Sinneswahrnehmungen und Sinnestäuschungen, von DR. KORN. Vogel und Kreienbrink, Leipzig, 1901. pp. 29.

A Text-book of Medicine for Students and Practitioners, by ADOLF STRÜMPELL. D. Appleton and Co., New York, 1901. pp. 1242.

This magnificent work, now in its third American and thirteenth German edition, and with 185 illustrations, is a well known standard work, which has been now almost wholly rewritten. It thus retains all the merits of the earlier production, while it has the advantage of being most nearly in line with recent investigations. It should have a place in the library of every physician. Its indexes and convenient arrangement of subject matter make everything accessible.

Textura del sistema nervioso del hombre y de los vertebrados, par S. RAMÓN CAJAL. Vol. I, pp. 566; Vol. II, pp. 224. Nicholás Moya, Madrid, 1899-1900.

At last we have a summary by the author of his neurological studies illustrated by 313 cuts, all of which I believe are entirely original. Fuller review will be given upon appearance of last half of volume.

Die psychologische Denkrichtung in der Heilkunde, von OTTO BINSWANGER. Deutsche Rundschau, Oct., 1900. pp. 87-103. Julius Rodenberg, Berlin.

Psychology and the Medical School, by GEORGE V. N. DEARBORN. Reprinted from science, N. S., Vol. XIV, July 26, 1901. pp. 129-136.

Journal of Medical Research, edited by Harold C. Ernst. N. S., Vol. I, No. 1, July, 1901. Boston.

The Works of George Berkeley, including his Posthumous Works. With prefaces, annotations, appendices, and an account of his life, by ALEXANDER CAMPBELL FRASER. In four volumes. pp. 527, 415, 412, 611. Clarendon Press, Oxford, 1901.

In 1899 Professor Fraser was asked by the delegates of the Oxford Press to preface a new edition of Berkeley's works with some account of his life, as the edition of 1871 was out of print. Although in his eighty-second year, having been for more than sixty years a lover of Berkeley, he undertook, and has now completed this work, utilizing all the valuable biographical and philosophical material, and also the invaluable manuscript of Archdeacon Rose. In this edition, the introduction and notes have also been almost entirely rewritten, although this is not intended to supersede the author's life of Berkeley. Much of the new material came in too late to permit of purely chronological arrangement which has, however, been mainly adhered to. On the whole, these volumes are attractive and convenient in form, and will be indispensable to all teachers of philosophy who have no earlier edition, and highly desirable for those who have.

Malebranche, par HENRI JOLY. F. Alcan, Paris, 1901. pp. 296.

The views of this great Cartesian, whom some think Berkeley's interview with him killed, are here presented in their unity. The many quotations are well chosen, and they attractively present the incomprehensibility of God, the soul, and the ideals of perfection.

Pour la Raison Pure, by F. EVELLIN. F. Alcan, Paris, 1901. pp. 34.

This is an attempt to summarize the many conflicts between imagination and reason.

Philosophie des Sichselbstbewusstsein, von FRIED. WILHELM DAHLMANN. Koelling und Klappenbach, Chicago, 1901. pp. 146.

This book with its fine German type, to our thinking, remarkably tasteless get up, its long paragraphs and sentences, with neither index or table of contents throughout, may have a very important message, and it may find somewhere a reader, both of which we sincerely hope.

La Philosophie Russe Contemporaine, par OSSIP-LOURIÉ. F. Alcan, Paris, 1901. pp. 278.

The first part describes philosophies and the general philosophy of Russia; the second is devoted to psychology; and the third to eleven sociologists, with a summary chapter urging the necessity of breaking away from isolation in Russia.

Geschichte der Philosophie im Islam, von T. J. DE BOER. E. Hauff, Stuttgart, 1901. pp. 191.

The geography of Islam is first treated; then oriental wisdom; Greek science; the views of Arabian philosophers on philology, duty, faith; the degree in which they were influenced by Pythagoras, Aristotle, Neoplatonism, which affected different Mahommedan thinkers in very different ways; and finally Arabian philosophy in the West.

Science and Mediæval Thought, by THOMAS C. ALLBUTT. C. J. Clay and Sons, London, 1901. pp. 116.

This is the Harveian Oration delivered before the Royal College of Physicians, October, 1900.

A History of Philosophy, with Especial Reference to the Formation and Development of Its Problems and Conceptions, by W. Windelband. Translated by James H. Tufts. The Macmillan Co., New York, 1901. pp. 726.

The translator has in this edition incorporated all the changes made by the author in the second German edition, whether in the text or the appendix. A seven page note on certain aspects of recent English thought has also been added.

L'Évolutionnisme en Morale, par JEAN HALLEUX. F. Alcan, Paris, 1901. pp. 228.

The first part discusses the principles of moral evolution and conduct from the physical, biological, psychological and sociological view point. The second part is the discussion of the hypothesis fundamental to the system and of the principles of conduct as deduced from it, with a final application to practical life.

Das sittliche Leben, von HERMAN SCHWARZ. Reuther und Reichard, Berlin, 1901. pp. 417.

This is an ethics on a psychological basis with an appendix on Nietzsche's Zarathustra doctrine. The first part characterizes the ethics of personal worth or the doctrine of modern self-affirmation; the second is entitled alien morals or the doctrine of ethical self-denial.

Varia. Studies on Problems of Philosophy and Ethics, by WILLIAM KNIGHT. John Murray, London, 1901. pp. 196.

The functions of philosophy at the present time; nationality as an element in its evolution; our present philosophical outlook; poetry and science, their contrasts and affinities; the unseen root of ethics; the correlation of moral forces; corporate responsibility; practical ethics; philosophical societies in the universities of Scotland; the formation of public opinion; desiderata in modern philosophy and the ethics of criticism, are the topics in this volume, made up of lectures to students at St. Andrews, one of which is given at the opening of each year.

Ethical Marriage. A Discussion of the Relations of Sex from the Standpoint of Social Duty, by DELOS F. WILCOX. Wood-Allen Publishing Co., Ann Arbor, Mich., 1900. pp. 235.

This little book embodies a protest against the idea that the morals of marriage are a subject to be discussed by physicians alone and as incidental to sexual pathology. The writer pleads that marriage is the supreme co-operation; that only the fittest should marry; describes its motives, the duties of courtship, the control of passion in marriage, with social reflections at the end.

Sexualethik, Sexualjustiz, Sexualpolizei, von KARL KENTSCH. "Die Zeit," Wien, 1900. pp. 95.

Das Sexuelle Leben der Naturvölker, von JOSEF MÜLLER. Lampart u. Comp., Augsburg. pp. 73.

Sexuelle Irrwege, von FERD. STEINGIESSER. Hugo Bermühler, Berlin, 1901. pp. 192.

These volumes are hardly scientific or philosophical, but are chiefly popular, and while they contain some things that are good, contain little that is new.

Questions de Philosophie Morale et Sociale, par J. P. DURAND. F. Alcan, 1901. pp. 179.

The venerable writer again describes materialism, atheism, determinism, socialism, transformatism, and "struggleforlifeism," with an appendix on the relations of psychology to metaphysics, morals and the subconscious, and the communal family.

The Doctrine of the Freedom of the Will in Fichte's Philosophy, by JOHN FRANKLIN BROWN. Richmond, Ind., 1900. pp. 105.

The Ethical Aspect of Lotze's Metaphysics, by VIDA F. MOORE. The Macmillan Co., New York, 1901. pp. 101.

These are interesting and valuable digests of their themes, which speak well for the high quality of the work done in the Philosophical Department of Cornell University, where both were produced.

Friedrich Nietzsche, von JULIUS REINER. Hermann Seeman, Leipzig, 1901. pp. 76.

His life and work as poet and philosopher are first described, and the latter is treated under the captions of religion, woman, the superman and morality.

Lectures on the History of Physiology during the Sixteenth, Seventeenth and Eighteenth Centuries, by M. FOSTER. University Press, Cambridge, 1901. pp. 310.

These lectures were delivered in the autumn of 1890 at the Cooper Medical College in San Francisco. The writer does not attempt to give a complete history of physiology, even within the period to which he has limited himself, but has selected certain themes that seem to him most striking and important. He has woven in interesting stories of the lives of Vesalius, Harvey, Borelli, Malpighi, Van Helmont, Sylvius, and other writers.

La Morale basée sur la Démographie, par ARSÈNE DUMONT. Schleicher Frères, Paris, 1901. pp. 181.

The chapters are entitled the crisis of morality, the crisis of modern science, the demographic criterion, the love of truth, alcohol, and moralization.

Inductive Sociology, by FRANKLIN H. GIDDINGS. The Macmillan Co., New York, 1901. pp. 302.

This book presents a scheme of inductive method, a detailed analysis and classification of social facts, and a tentative formulation of the more obvious laws of social activity,—all as a basis for further inductive studies. The first book treats the elements of social theory; the second, the elements and structure of society. Under the latter, part one deals with the social population; part two, the social mind; part three, organization; and part four, welfare.

The Primer of Political Economy, by S. T. WOOD. The Macmillan Co., New York, 1901. pp. 149.

This volume seeks to lay ground work for political study and explain some of the actual economic phenomena passing through our hands from day to day that their laws, principles and relationships may be more independently studied and more clearly understood. They are addressed to the fourth form of public schools and treat the herdsman of the plains; how oil is obtained; mining, rubber, shoemaking, taxation, coin, banking, stock companies, and many other topics.

Select Documents of English Constitutional History, edited by George Burton Adams and H. Morse Stephens. The Macmillan Co., New York, 1901. pp. 555.

This is to meet the needs of teachers of English constitutional history. The great question in this work, as the previous English selections by Stubbs, Prothero and Gardiner have shown, is to make the proper selection. These authors have followed a plan of their own, and we think with wisdom and discretion.

Notre Armée, von ÉMILE MANCEAU. Bib. Charpentier, Paris, 1901. pp. 425.

This psychological study of the French army considers first the officers, the methods of recruiting, advancement, their relations to the nation; then the sub-officers and soldiers, the instruction of the latter and the duration of military service. The spirit of French military institutions, the constitution of the army, and other topics are treated.

Psychologie d'une Ville, par H. FIERENS-GEVAERT. F. Alcan, Paris, 1901. pp. 189.

This is a psychological study of the town of Bruges, and describes the birth and adolescence of the city, its art, men and events of the thirteenth century, its democracy, realism, painting, luxury, moral life, architecture, etc.

Die Religionen der Völker, von H. BERKENBUSCH. A. Kiepert, Hannover, 1901. pp. 100.

This pamphlet discusses the religion of Babylonians, Phœnicians, Canaanites, Israelites, Arabians, Egyptians, Chinese, East Indians, Iranians, Greeks, Romans, and Germans.

Die Anfänge unserer Religion, von PAUL WERNLE. J. C. B. Mohr, Tübingen, 1901. pp. 410.

Under the origin of religion are discussed Jesus, his calling, the promise, his function as redeemer, the primitive Christian community, Paul, the theology of redemption, the anti-Judaic apologetics, the apocalypse, the development of the church and theology, and piety in the post-apostolic age.

Magic and Religion, by ANDREW LANG. Longmans, Green and Co., New York, 1901. pp. 316.

This is the nineteenth volume of this voluminous author and editor, which the Longmans have published. The writer points out in the first paper the danger of allowing ourselves to be led astray by too ingenious hypotheses. The next two papers strengthen his well known theory that the first traceable form of religion was high and was lowered in the process of evolution. He still polemizes in the forty-five pages against Taylor and Frazer. South African religion, taboos, the ghastly priest, fire walk, cup and ring, cavalry;—these constitute the most important papers.

Die Entwicklung der Religionsbegriffe als Grundlage einer progressiven Religion, von STEFAN VON CZOBEL. Vol. I, pp. 578; Vol. II, Part 1, pp. 288. Lotus-Verlag, Leipzig, 1901.

The writer premises that religion begins in the origin of supersensual ideas and a belief in supernatural beings, and gives what he terms a rational formulæ of development, and then treats successively the religion of the Akkadians, Egyptians, Assyrians, Phœnicians, Jews, Medes, Persians, Indians, Greeks, Romans, and finally Christianity. It is a unique attempt to regard the religions of ancient and modern times from the standpoint of evolution.

The Old Testament from the Modern Point of View, by L. W. BATTEN. E. S. Gorham, New York, 1901. pp. 354.

The writer first treats the general arguments against the validity of critical results, then the hexateuch, history, prophets, and psalms, with a final chapter on criticism and the supernatural.

The Life and Literature of the Ancient Hebrews, by LYMAN ABBOTT. Houghton, Mifflin and Co., Boston, 1901. pp. 408.

The chief topics are the Bible as literature, Hebrew history, prehistoric traditions rewritten, book of the covenant, the Deuteronomic code, the canon law, Hebrew fiction, stories retold, a drama of love, a spiritual tragedy, a school of ethical philosophy, a collection of lyrics, preachers of righteousness and redemption, the message of Israel. Two tables, one giving the order of the writings of the Old Testament and the other its chronology, are prefixed.

Leben Jesu, von D. OSCAR HOLTZMANN. J. C. B. Mohr, Tübingen, 1901. pp. 428.

This is a very judicious and learned summary of the sources, turning points, early history, the Baptist, Jesus' baptism, temptation, the nearness of the kingdom, the preaching in Galilee, the calling of the Twelve, the visit to Jerusalem, proclamation as Messiah, death and resurrection.

Studies of the Mind in Christ, by THOMAS ADAMSON. T. and T. Clark, Edinburgh, 1898. pp. 300.

What was the knowledge which our Lord had as a man is a question which can be investigated without disrespect to Christ? We are not at liberty to believe that divinity did the work of humanity or in any respect rendered it less human. From this point of view our author discusses Christ's ignorance; his real and apparent supernatural knowledge; his divine and spiritual knowledge; his knowledge of the Old Testament; of the future; the boundedness of his knowledge; his self guidance; plan; his traits as a miracle worker; and his mental identity after his resurrection.

Is Christ Infallible and the Bible True? by HUGH M'INTOSH. T. and T. Clark, Edinburgh, 1901. pp. 719.

The question which forms the title of this book is for the author the supreme and most urgent question in the world. He does not hold to absolute inerrancy, but throughout his teaching is highly conservative. His work is essentially argumentative, and is directed mainly against the leaders of the liberal school.

The Divinity of Christ. An Argument. Translated from the French of Mgr. Emile Bougaud, by C. L. Currie. William H. Young and Co., New York, 1901. pp. 159.

The author here seeks to present Christianity in a form suited to the present time. He desires to describe its polity and unfold its creed, and assumes throughout that religion only requires to be known to be welcome. It was written when the author was about fifty, and is the product of a soul overflowing with benignity and adoration. The substance of its ten chapters was no doubt often preached, and their point of view is somewhat hortatory.

Jesus Christ and the Social Question, by FRANCIS GREENWOOD PEABODY. The Macmillan Co., New York, 1901. pp. 374.

These seven chapters are somewhat sermonesque, but abound in indications of the author's study of the problems of modern social life, and are predominantly a study of the views of Jesus.

The Historical New Testament. A new translation by James Moffatt. Charles Scribner's Sons, New York, 1901. pp. 726.

The writer has arranged the New Testament in the order of its literary growth and indicated at the same time the chief grounds upon which such order is determined. He has also given us a new translation. It is difficult to speak too highly of the care with which this work is executed. The writer has taken pains to possess himself of most of the authorities and theories bearing upon the subject. His introductions are succinct, and he has constructed many very interesting tables which are perhaps on the whole the best thing in the volume, which ought to be in the possession of every student of the New Testament.

Ad. Harnacks Wesen des Christentums für die christliche Gemeinde geprüft, von D. WILH. WALTHER. A. Deichert, Leipzig, 1901. pp. 168.

This volume, larger than that to the refutation of which it is devoted, Harnack calls the best and ablest of all the many attacks upon his famous lectures to students. The author is the Professor of Theology at Rostock, and especially attacks Harnack's disbelief in miracles; his statement that Jesus brought no essentially new message; that he does not exactly belong in his own gospel; did not arise from the dead; that his death was not an atonement; and that Paul in some respect injured the gospel.

Das Christentum, von D. Ad. Harnack nach dessen sechzehn Vorlesungen, von ED. RUPPRECHT. E. Bertelsmann, Gütersloh, 1901. pp. 278.

These sixteen lectures contain an exceptionally pietistic refutation of Harnack, who is overwhelmingly refuted by dogmatic assertions and well rebuked and reproved.

Das Wesen des Christentums und die Zukunftsreligion, von LUDWIG LEMME. Edwin Runge, Berlin, 1901. pp. 218.

These seventeen discourses on Christian religiosity and the absolute, or future religion, are essentially evangelical. The student and the pietist will find little new here.

The Soul of a Christian, by FRANK GRANGER. The Macmillan Co., New York, 1900. pp. 303.

The writer has saturated himself with Christian mysticism, and has taken some, though too slight, account of modern psychology, and writes chapters on the oversoul, the depths of the soul, its awakening, its dark night, ecstacy,vision and voices, human and divine love, symbol and ritual, inspiration and prophecy, illumination and progress, confession, casuistry mystical theology. He is a man who has had deep religious feeling, and has struggled and groped his way to profound insights and made interesting points of contact between the best type of mysticism and modern psychology. For all those interested in the new field here opening, this volume will be very stimulating, although very unsatisfying.

Christentum und Darwinismus in ihrer Versöhnung, von HERMANN FRANKE. A. Duncker, Berlin, 1901. pp. 128.

This was suggested by Harnack's famous lectures on the essence of Christianity. Accepting this view in the main, the writer contrasts it with evolutionism, but finds that the more liberal the views of Christianity become, the more they harmonize with the development hypothesis. This is traced in the evolution of religion, of revelation, of Christianity, and of morals.

Das Christentum als Religion des Fortschritts, von CHR. A. BUGGE. J. Ricker, Giessen, 1900. pp. 67.

The writer proves his thesis in two ways, both treated in an inspiring way; first, the social programme of Paul, and second, the inspiration of the Bible.

Enthusiasmus und Bussgewalt beim Griechischen Mönchtum, von KARL HOLL. J. C. Hinrichs, Leipzig, 1898. pp. 331.

Enthusiasm among the Greek monks; the discipline of penance and confession are the topics of chief interest here treated.

Monuments of the Early Church, by WALTER LOURIE. The Macmillan Co., New York, 1901. pp. 432.

This interesting volume is fully up to the level of the other six hand-books of archæology and antiquities, which have so far appeared. Christian cemeteries, the basilica, pictorial art, early painting, sculpture, mosaics, miniatures, the minor arts, and ecclesiastical dress are the leading topics, with 182 illustrations.

Theologie und Metaphysik, von GEORG WOBBERMIN. A. Duncker, Berlin, 1901. pp. 291.

The first part treats of epistemological investigation concerning the idea of metaphysics and its significance for theology. The second part treats of *empirio* criticism as the outcome and self criticism of anti-metaphysical thought as treated from the standpoint of theological interest. The third part deals with the fundamental problems of metaphysics and their importance for theology, especially the problem of the self and causality.

Die Idee des Reiches Gottes in der Theologie, von JOHANNES WEISS. J. Ricker, Giessen, 1901. pp. 155.

This is an amplified lecture delivered at a theological conference in Giessen, and is in a sense supplementary to the author's treatise on Jesus' teachings concerning the Kingdom of God.

La Vie future d'après le Mazdéisme, par NATHAN SÖDERBLOM. (Annales du Musée Guimet, Vol. IX.) Ernest Leroux, Paris, 1901. pp. 447.

This study of comparative eschatology is one of the best of the many excellent productions of this unique institution.

A Century's Progress in Religious Life and Thought, by W. F. ADENEY. Jas. Clarke and Co., London, 1901. pp. 229.

The chief topics here treated are the Oxford movement; the relations between religion and science; Biblical criticism; the imminence of God; the decline of Calvinism; changed views of redemption; with other chapters on preaching and preachers; leading minds of the century, etc. The writer has evidently lived into his subject long and well.

Glauben und Wissen, von EMIL FISCHER. Handel, Bamberg, 1901. pp. 232.

The chief topics are Japanism; woman as a teacher; Goethe's relation to religion; Bible criticism and religious education; the death penalty; is there a life end or purpose? patriotism and Tolstoi, anarchy, faith and knowledge; what is going to happen?

La Crise de la Croyance, par ALBERT BAZAILLAS. Perrin et Cie, Paris, 1901. pp. 307.

The philosophy of certitude and of life according to Olle-Lapreune; the life of belief according to Newman and Arthur Balfour;—these are

For Sunday School Workers, by A. F. SCHAUFFLER. With a foreword by the late Dwight L. Moody. W. A. Wilde Co., Boston, 1901. pp. 283.

Like all the author's other publications, this book is largely made up of talks to Sunday School teachers. The last half of the book is in part written by other hands, and Rev. A. H. McKinney contributes three interesting chapters on the study of the child. On the whole it is a volume of devices and exhortation, and deals little with pedagogical principles.

Mission Problems and Mission Methods in South China, by J. CAMPBELL GIBSON. Oliphant, Anderson and Ferrier, Edinburgh, 1901. pp. 332.

These are lectures given by appointment of the General Assembly of the Free Church of Scotland. Interesting are the chapters on Chinese literature, philosophy and religion, and the first three stages of mission work. The writer's field of view is limited to that of the English Presbyterian mission. The book contains sixteen illustrations.

Das Spätere Judentbum als Vorstufe des Christentbums, von W. BALDENSPERGER. J. Ricker, Giessen, 1900. pp. 30.

Das Biblische Paradies, von B. POERTNER. Franz Kirchheim, Mainz, 1901. pp. 36.

Die Offenbarung im Gnosticismus, von RUDOLF LIECHTENHAN. Vandenhoeck und Ruprecht, Göttingen, 1901. pp. 168.

Kultus- und Geschichtereligion, von JOH. JÜNGST. J. Ricker, Giessen, 1901. pp. 79.

Die Motive des Glaubens an die Gebetserhörung im Alten Testament, von JUSTUS KÖBERLE. A. Deichert, Leipzig, 1901. pp. 30.

Die Geburts- und Kindheitsgeschichte Jesu Luc. 1,5-11, 52, von A. HILGENFELD. pp. 177-235.

Das Wesen des Christentums, von GEORG REINHOLD. Jos. Roth, Stuttgart, 1901. pp. 96.

Beiträge zur Geschichte und Erklärung des Neuen Testamentes, von C. F. GEORG HEINRICI. Dürr, Leipzig, 1900. pp. 81.

Lehrbuch der Neutestamentlichen Theologie, von HEINRICH JULIUS HOLTZMANN. Vol. II, pp. 532. J. C. B. Mohr, Freiburg, i. B., 1897.

Zwei akademische Vorlesungen über Grundprobleme der systematischen Theologie, von GEORG WOBBERMIN. Alex. Duncker, Berlin, 1899. pp. 43.

Das Mönchthum seine Ideale und seine Geschichte, von ADOLF HARNACK. J. Ricker, Giessen, 1901. pp. 60.

The Philosophy of Religion in England and America, by ALFRED CALDECOTT. The Macmillan Co., New York, 1901. pp. 434.

Die Selbständigkeit der Dogmatik gegenüber der Religionsphilosophie, von LUDWIG IHMELS. A. Deichert, Leipzig, 1901. pp. 34.

SUBJECT INDEX.

CORNELL UNIVERSITY.

Courses of Instruction offered by the Department of Psychology for the academic year 1901-2.

(1) Introduction to Psychology: Sophomore Course. Lectures and demonstrations. Three hours, first third of year. Professor Titchener.

(2) Experimental Psychology: Junior Course. Laboratory work, with occasional lectures. Three hours throughout the year. Professor Titchener, Dr. Bentley, Dr. Whipple and Mr. Baird.

(3) Genetic Psychology. Lectures. Two hours. Dr. Washburn.

(4) Reading of German Psychology. One hour, second half of year. Professor Titchener.

(5) Systematic Psychology: Senior Course. Lectures, essays, and experimental demonstrations. Three hours throughout the year. Professor Titchener, Dr. Bentley and Dr. Whipple.

(6) Laboratory exercises in Psychology. Hours (one to five) to be arranged. Professor Titchener, Dr. Bentley, Dr. Whipple and Mr. Baird.

(7) History of Psychophysics. Lectures. One hour, second half of year. Dr. Bentley.

(8) Social Psychology. Lectures. One hour. Dr. Washburn.

(9) Seminary in Psychology and Advanced Laboratory Work. Daily, throughout the year. Professor Titchener, Dr. Bentley, Dr. Whipple and Mr. Baird.